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President's Column

An historic step was taken at the National Meeting of Concern for Science and Technology which was sponsored by and held at the Academy of Sciences, Canberra on 16 April.

Representatives of 68 scientific and technological societies resolved to form a Federation of Australian Scientific and Technological Societies. The background to this decision has already been reported in the Australian Physicist and, largely speaking, is the outcome of the mounting concern of the scientific and technological community at its lack of impact on government in matters of science policy, particularly funding, and of its poor public image.

An Interim Committee was elected, charged with the responsibility of drafting a constitution and I was honoured to be asked to act as its chairman. I see this not merely as a personal honour but more as a recognition of the leading role that the Institute has taken in stimulating discussions of science policy. The membership of the committee was carefully selected to be representative of the wide diversity of scientific and technological disciplines involved and also to ensure that both the small and large societies were appropriately represented. The importance of an input from Industry was fully recognised and specific provision was made for representation on the Interim Committee. A full report of the meeting and the resolutions passed will be published in the Australian Physicist.

I do not pretend that the task ahead for the Interim Committee is going to be easy. It will require understanding and good will by all concerned to arrive at a constitution that is fair to all. It must also be recognised that the Federation is for the benefit of all members of the scientific and technological societies and is not a vehicle for promoting the restricted aims of a specific group.

All the societies represented at the National Meeting have been invited to present their views to the Interim Committee on the most appropriate mechanism for representation on the Executive Board of the Federation and its size. The views of individual members of the Institute are also invited.

While the motivation for the establishment of the Federation has been largely political, I foresee wider benefits in the interaction between the various sectors of the scientific and technological community that its formation will foster.

Jed Smith

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Editorial

Anyone who reads the Australian Physicist will know that there are many conferences and meetings in Australia. I have just been to one in Adelaide, en route to visit other laboratories and people, and to carry out necessary tasks in other States. Such an exercise is a costly one, especially for those of us in Western Australia, and I sometimes wonder if it is worth it.

There is no doubt that distance is a tyrant from the point of view of expense and inconvenience, but it exercises its tyranny in more subtle ways. Whether it consists of kilometers, or red tape, or unfriendliness, or secrecy, distance prevents the cross-fertilization of ideas without which progress all but ceases. A few minutes of conversation can trigger an idea or lay a cherished research scheme to rest; it can advise of new tools or techniques, or new ways of using old ones. Letters or phone calls can sometimes have a similar effect, but they lack the spontaneity of a face-to-face conversation, and they seldom allow us to make new contacts. Published papers are necessary, but not sufficient, because they usually lack the intimate details, and in any case may be too late to be of service. Only through discussion can the importance of particular research fields or the needs of certain industrial processes or the value of scientific products be appreciated. In primitive times, just a mountain range was often a barrier to ideas, culture, architecture and even language, and today, in matters which do not attract the attention of the mass media, we should still not underestimate the effects of isolation.

The AIP tries in a small way to address this problem through its Branch activities and through the Australian Physicist.

My time as Editor is coming to an end, and the executive is looking for a person who enjoys reading widely in physics and related sciences to take over. That is probably the most important pre-requisite for the job. We are open to suggestions and offers from suitable people, for short or long periods; and would be prepared to consider ideas which involve an honorarium for someone not in full-time employment; however, some energy maturity and experience in physics is required. Knowledge of publishing or editing is not needed — we can soon fix that!

Jim Graham

The low power (~1 mW) helium-neon laser is finding increasing use in the undergraduate laboratory as a light source for optics experiments. It eliminates much of the frustration and tedium that students used to experience in adjusting optical components to view diffraction and interference effects with incoherent sources. By using laser sources, students can concentrate on making measurements and studying the optical effects themselves. Introduction of lasers into the undergraduate laboratory also provides motivation for students, as well as training in a rapidly developing technology. Another teaching use of the low power helium-neon laser, which makes use of its narrow intense beam as well as its coherence, is in the demonstration of optical phenomena to a large class.

A wide range of laboratory experiments and class demonstrations has been developed, and information on these is well documented in books and journals. This article concentrates on a personal choice of substantive experiments suitable for second and third year undergraduate laboratories. The material is presented in five parts:

1. A guide to the available literature on demonstrations and experiments.

2. A description of an experiment which deals with the helium-neon laser itself, in particular, its mode properties.

3. Descriptions of experiments on interferometry, concentrating on lesser known interferometer arrangements.

4. Comments on laser safety procedures in the undergraduate laboratory.

5. Information on the availability of optical components using helium-neon lasers is available in books, reviews and journal articles. Most of the reviews and articles are published in the American Journal of Physics (AJP), and a few in Physics Education, The Physics Teacher and Scientific American. Some manufacturers of lasers have published their own books of experiments. I have found that the most comprehensive and useful sources of information are two publications of the American Association of Physics Teachers (AAPT). In one of these — Lasers: Selected Reprints (OShea and Peckham, 1982) the authors have brought together a selection of teaching articles on lasers, mainly from AJP. The first article is a Resource Letter which lists over 200 references on books, films and papers, on equipment, demonstrations and experiments. Also included are references to background reading on lasers, courses on lasers, and laser safety. The Resource Letter is an excellent source of information for anyone preparing a laboratory or lecture course in lasers, through to the post-graduate level.

The Resource Letter is followed by six articles of historical interest. They include Einstein's 1917 paper on the quantum theory of radiation, Schawlow and Townes' 1958 paper on the extension of laser techniques to the optical region, the first paper by Javan et al on the helium-neon laser and Maiman's first paper on the ruby laser.

The main content of the book deals with experiments and demonstrations using helium-neon lasers, and 26 articles have been chosen, mainly from AJP. They include a paper on how to cure a dying helium-neon laser, Schawlow's famous paper on how to measure the wavelength of light with a ruler, a paper describing how to make your own spatial filter, plus papers on diffraction, interference and holography. There are no papers which deal with the properties of the helium-neon laser, most of those available having appeared since Lasers: Selected Reprints was published. The authors have made an appropriate choice from a very wide selection. I presume that one criterion in their choice was that the experiment or demonstration did work; and all that I have tried, have indeed worked well. The final paper in the book is on laser safety.

The second AAPT publication which I have found useful in preparing laser experiments is Exploring Laser Light (Kallard, 1982). There is some overlap between it and Lasers: Selected Reprints, but the former is more general, if less exact. It contains 120 articles, each 1 to 2 pages long, dealing with demonstrations and experiments using a low power helium-neon laser. Topics covered include laser properties, power meters, detectors, measurements of refractive index, polarization, interferometry, diffraction and holography. The book includes also a list of U.S. suppliers of lasers and optical components, and a useful bibliography. Exploring Laser Light is excellent for demonstrations, but less so, for laboratory experiments, because of a lack of detailed information. Some of the information, including diagrams, is incorrect, the notation used is inconsistent, and a number of the demonstrations and experiments do not work. Nevertheless the wide
coverage of the book makes it a useful source of information, when used with discretion.

Further papers on laser demonstrations and experiments have of course appeared in the literature since these two books were published. The more interesting of these are concerned with the properties of the helium-neon laser—its modes (Ruddock, 1980; Woolsey et al 1982) and 633 nm line structure (Steinhaus, 1983), and with beam deflection in a thermal gradient (Tennakone, 1983; Spagna, 1983).

2. An experiment on laser modes

The typical low power helium-neon laser found in the undergraduate laboratory uses a discharge tube with fixed mirrors sealed to its ends. Such lasers are normally adjusted to operate in cylindrically symmetric axial modes. Typical low power internal-mirror helium-neon lasers operating at 633 nm, have cavity lengths such that two or three axial modes are excited simultaneously. After such a laser is switched on, there is a period of up to about an hour, during which the temperature of the glass laser tube rises so that the tube slowly expands longitudinally. The cavity therefore lengthens and this causes the axial modes to pass inside the Doppler line of the output. The total output intensity is affected little by this mode switching. If, however, the output beam is passed through a polarizer, then for particular orientations of the polarizer, substantial fluctuations are observed in the intensity transmitted through the polarizer. These fluctuations occur, because successive longitudinal modes are linearly polarized, with alternate modes following two perpendicular directions \( \sigma \) and \( \alpha \). If the polarizer is placed in the path of the laser beam with its transmission axis parallel to one of the directions of polarization (\( \sigma \) or \( \alpha \)), the passage of the modes within the Doppler line can cause intensity fluctuations as high as 40% of the mean intensity. The intensity of a Spectra-Physics Model 155 laser transmitted through a polarizer oriented in this manner is shown as a function of time in Fig. 1, together with a series of schematic diagrams which illustrate how these intensity variations may be correlated with changes in mode structure within the Doppler line.

By using the experimental arrangement shown in Fig. 2, it is possible to measure, during the laser warm-up period, the beam polarization, cavity length, and tube temperature for an internal-mirror helium-neon laser, and to correlate the three sets of measurements to show their interdependence. Details of the experiment are presented elsewhere (Woolsey et al 1982), and only a broad outline is given here. The output of the laser beam is examined after transmission through a suitably oriented polarizer as described earlier. The linear expansion of the laser cavity is monitored by measuring the change in position of each of the end mirrors using a Michelson interferometer. The three sets of optical measurements, one of the laser output and two of the movement of the end-mirrors, can be made either simultaneously, or separately, since repeatability is good. The variation in laser output and the interferometer signals can be monitored visually, or by using apertures and photodetectors as shown in Fig. 2, with the outputs of the photodetectors displayed on an x-t chart recorder. The temperature of the laser tube is conveniently measured along its length using thermocouples.

One interferometer fringe shift, and one mode switch, occurs for each \( \sqrt{2} \) change in cavity length. This means that at any time after tube switch-on, the sum of the two fringe shifts should equal the number of mode switches, and the increase in tube length equals this number times \( \sqrt{2} \). For a Spectra-Physics Model 155 helium-neon laser of tube length 27.4 cm, the number of mode switches measured in 30 minutes of warm-up from room temperature is around 70, and this number agrees closely with the measured sum of the interferometer fringe shifts. The increase in tube length determined from this optical data agrees to within 5% with that calculated from Le\( \Delta T \), where \( L \) is the tube length, \( \Delta T \) is the thermal expansion coefficient of the glass of the laser tube (usually Pyrex), and \( T \) is the increase in mean tube temperature; the latter is determined from the thermocouple measurements of tube wall temperature as a function of position along the tube.

3. Laser Interferometry

Discussion of optical interferometry in teaching articles usually concentrates on Michelson and Mach-Zehnder systems. Several manufacturers produce teaching systems which are primarily Michelson interferometers, but which include a facility for modification to Twyman-Green or Fabry-Perot arrangements. Lesser known types of interferometer are the Jamin, and those which use polarizing prisms. In many respects, they are more appropriate for undergraduate use than the more conventional types. This is because Jamin and polarization interferometers are easier to align, are more stable, and can be used over longer optical paths. Another advantage of the Jamin interferometer, in the form described here, is that it can be put together very cheaply. A disadvantage of the Jamin and polarization systems is that they have limited shear, although this does not seem to be a problem in the undergraduate laboratory.

A polarization interferometer, (Francon and Mallick, 1971) which uses two Wollaston prisms and two converging lenses, is shown in Fig. 3a. A Wollaston prism is made up of two calcite prisms cemented together with their crystal axes perpendicular. They can be obtained with angular shears of between 5° and 20°. The optical quality of the lenses is not critical. Because reflection plays no part in this interferometer, it is relatively insensitive to vibration of its components, and long paths can be used without the need for an optical table.

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A modified Jamin interferometer, (Woolsey, 1973) as shown in Fig. 3b, can be assembled from two cheap, readily procurable, glass plates of nominally the same thickness, and each with a wedge angle of approximately 1 or 2 minutes of an arc; this is the usual degree of parallelism found with such plates. The plates are positioned with their wedge angles anti-parallel and fringes are formed with a separation dependent on the wedge angles of the plates. This is different to a conventional Jamin arrangement (Bnaud Wolf, 1965), which uses expensive plates of high quality and uniformity with regard to refractivity, flatness, and parallelism of their opposite faces. Interference fringes are then produced by tilting one plate through a small angle relative to the other about an axis parallel to the plane of the diagram in Fig. 3b.

Because both beams of the jamin interferometer pass through the same two plates, any translational motion of either plate does not affect the optical path difference between the beams even when long paths are used. The path difference is changed only by rotational vibration of either plate about a vertical axis through its centre (normal to the plane of Fig. 3b) and this is a negligible effect under normal laboratory conditions.

Both the polarization and Jamin interferometers are therefore ideal arrangements for experiments in a crowded undergraduate laboratory. Either may be used, for example, to measure the refractive index of a gas (Woolsey, 1973). A metal vacuum chamber terminated by glass plates may be placed in the path of one interferometer beam. As air is admitted to the chamber through a needle valve, so that the pressure rises from backing pump pressure (~10⁻³ torr) to atmospheric pressure, the fringe shift can be measured. Using the relation \( \Delta n = \frac{m \lambda}{l} \), where \( l \) is the chamber length and \( m \) is the fringe shift, the refractive index \( n \) can be determined. A chamber of 10 cm length will give a fringe shift of about 40, and a value for \( \Delta n \) within 1% of the accepted value.

A third interferometer, appropriate for the undergraduate laboratory, is the Fizeau, which is used in optical workshops to test the uniformity of optical thickness of glass plates. A Fizeau interferometer can be used to determine the wedge angle of a glass plate (Woolsey, 1973), as shown in Fig. 3c. The laser output is expanded by a beam expander or microscope objective \( L_1 \), and a broad parallel beam produced by a convex lens \( L_2 \). The plate is tilted slightly from the normal to the incident beam so that the fringe pattern produced by reflections from the two plate surfaces is projected on to a screen by lens \( L_2 \). The angle of tilt is small enough, however, that the cosine of the angle of incidence to the plate may still be taken as unity.

The fringe separation at the plate is given by

\[
x = 4d \Delta \Phi
\]

where \( d \) is the separation measured at the screen, \( f \) is the focal length of lens \( L_2 \), and \( D \) is the distance between \( L_2 \) and the screen. Since \( x \) is related to the wedge angle of the plate, \( \theta \), by \( x = \frac{\lambda}{2\mu} \theta \) (where \( \lambda \) is the wavelength of the incident radiation and \( \mu \) is the refractive index of the glass plate), a measurement of \( d \) allows \( \theta \) to be calculated. The orientation of the fringes gives the orientation of the wedge angle of the plate. Using a beam diameter of the order of 1 cm, wedge angles as small as a few seconds of an arc can be measured.

4. Safety procedures

A laser beam entering the eye is focused to a tiny spot on the retina, and even a 1 mW helium-neon laser produces intensities at the retina that may be 10⁷ times those of conventional light sources (Weichel et al. 1974). An exposure of only hundredths of a second will deposit enough energy to injure several hundred rods and cones.
in the retina. It is important therefore to minimize the possibility of the eyes of students, and teachers, being exposed to direct or reflected beams of laser radiation. This can be done by operating helium-neon lasers in the undergraduate laboratory according to a sensible set of procedures, without the need to be overly restrictive. The procedures listed below can readily be incorporated into the running of an undergraduate laboratory. They refer, however, only to the use of low power helium-neon lasers, and where lasers of higher power or other wavelengths are used, more stringent safety procedures will generally be required (Weichel et al, 1974).

(i) Laser experiments should be placed together either in one area of the laboratory, or in a separate laboratory. Ideally, each experiment should be in a separate room. Failing that, partitions should be in place so that no laser beam can stray from one experiment to another.

(ii) Warning signs should be posted adjacent to the area used for laser experiments, and access to that area restricted to students working on those experiments.

(iii) Room illumination should be as high as possible. This keeps the pupil of the eye small, so that the damage to the retina caused by any accidental exposure to laser radiation is minimised.

(iv) Windows through which any laser beam might possibly stray should be covered.

(v) Laser experiments should be assembled on benches in such a way that all beams are below eye-level.

(vi) Highly reflective objects, including jewellery and watches, should be removed from the vicinity of any laser equipment.

(vii) Where possible, the walls and partitions in laser laboratories should be painted a flat, off-blue colour. The blue will minimize reflection of the red helium-neon laser radiation and the flat texture will reduce specular reflection.

(viii) Students should be advised about the hazard to their eyes, and about the above procedures. In particular, they need to be warned not to look along a laser beam when aligning optical components.

5. Availability of components

Some manufacturers of optical equipment produce kits of components in various forms, which are useful for the assembly of optics experiments using helium-neon lasers. These include kits of a general nature, as well as those designed for particular topics such as interferometry and holography. On the other hand, substantive experiments suitable for second and third year undergraduate laboratories are more likely to be assembled from individually purchased components. Helium-neon lasers and optical components are manufactured by many companies in the U.S.A. and Europe, and by a few in Australia. Most overseas companies have Australian agents. All advertise widely in the physics journals, but should you have a problem in locating any particular item of equipment, please write to me; I might be able to help. With regard to some of the more specialized pieces of equipment referred to in this article, their availability is as follows. Interferometer teaching units are produced by Ealing Optics and Pasco Scientific at a cost of around $3,000. Beam expanders (without spatial filtering) are available from Oriel at around $400. Wollaston prisms are made by Karl Lambrecht and B. Halle Nachfl., and vary in price between $500 and $700.

References


AUSTRALIAN INSTITUTE OF PHYSICS

21st PAWSEY MEMORIAL LECTURE

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THE CENTRE OF OUR GALAXY: IS IT A BLACK HOLE?

will be given by

DR RONALD C. MORTON, Director, Anglo Australian Observatory

at 6.00 pm on Tuesday, 38th June, 1985

in the Keith Burrows Lecture Theatre

University of N.S.W.

The speaker will be the guest of the A.I.P. at a dinner to be held after the lecture. Members wishing to attend this dinner are asked to contact the N.S.W. Branch Secretary, Mrs Moira Welch, on phone 487-3488

The Australian Physics, Vol. 22, May 1985 — Page 133
INTRODUCTION

The majority of physicists on the Australian Institute of Physics (AIP) membership list is employed by government, as academics or researchers. As such, many of these may have little appreciation of the peculiar challenges and obstacles confronting Australian physicists working in heavy industry. To remedy this imbalance, the Science Policy Committee has attempted to gather the personal experiences of a range of physicists in heavy industry. The emphasis of the survey was not so much on what physicists were doing or could be doing in heavy industry, but on the challenges and handicaps, rewards and disappointments they face in their work.

One particular problem in selecting respondents was that many AIP members, especially non-academic members on the AIP mailing list, provide only their home address; for whom they work is not recorded. Only twenty-five physicists could be contacted and of these only seven replied. However, five of these seven replies ran to several pages. Obviously the following report has little statistical significance, because of the small numbers involved, nor can it truly claim to represent the collective opinion of physicists in heavy industry, since many industries and experiences were not represented.

The report remains a collection of personal experiences, which nevertheless may prove useful, in discussing some of the perceived gaps between pure and applied research and in foregrounding physicists seeking employment in industry. Where possible the actual words of respondents are used though these are not placed within quotation marks, to improve continuity and preserve a guaranteed anonymity. Consequently, the report at times may seem contradictory, since many of the opinions varied. The great majority of comments included are not those of members of the Committee, nor does the Committee necessarily endorse them. They are presented to stimulate discussion and to challenge other physicists in industry to contribute to further debate.

The term heavy industry initially caused some confusion. The Committee intended to distinguish the work situation of big industrial companies from the myriad of small companies in Australia, in particular to distinguish between established large industries and new high technology, such as computing.

The main industries initially considered were mining, mineral exploration, bulk fuels, heavy transport, manufacturing of bulk materials, and heavy engineering. The industries represented by the respondents were unfortunately less widespread than this.

Respondents were asked to comment on the long term social and political contexts of work in heavy industry, such as the level of industrial R&D and long term employment prospects. Few chose to do so, concentrating on more limited personal horizons. While this may indicate a lack of awareness of the larger issues, on the part of physicists concentrating their efforts within a narrow field of interest, it may more likely exemplifies the hesitancy of many physicists to comment on areas in which they consider they lack expertise.

The various comments fell generally within seven related topics: the need to achieve a balanced public image of the physicist, particularly as a physicist working in industry, the variety of career paths for physicists in industry; the skills required of physicists working in industry, whether higher degrees are an advantage or disadvantage, and the possibility of managed postgraduate study in undergraduate and postgraduate work; how the work situation for physicists in industry compares with that of physicists in other large organizations; and finally, some comments on academic research. The Committee regrets that more physicists did not take the opportunity to contribute to the survey. The issues raised by those who did reply are relevant, not only to the physicists concerned and to Australian industry but also to the way academics and the public perceive the role of physics in industry.

THE IMAGE OF ‘THE PHYSICIST’

Certain stereotypes of physicists have produced a particular image in the community of what a physicist is. The image is one of high science: atom smashing with giant accelerators, quark counting, relativivity, laser experiments. It would seem that physicists have never been good at presenting an image for other than conventional academic roles. The less spectacular forms of physics, and the less spectacular physicists, have for the most part been lost from the public view. Since most industrial employers are not immediately interested in atom smashing, they will tend to employ an engineer rather than a physicist. It may also be that what most of us conceive of as physics is often not relevant to industry, so that after a few years physicists tend to look, and communicate, like engineers, chemists.

One factor contributing to the anonymity of physicists in industry is the widespread lack of the term ‘physicist’ in job titles. Most industries have engineers, metallurgists and chemists but most physicists become experimental officers or research officers, etc. One respondent, currently a senior research officer, commented that in his opinion ‘research scientist’ was a suitable compromise. If physicists should ever come to dominate the technical effort of heavy industry to the extent that engineers do today, he felt, then the change in job title would follow automatically; the implication being that anonymity results from low numbers. Related to this, is the tendency for physicists in industry to grow in small colonies, somewhat akin to Drane’s hypothesis of Multiplicative Creation.

One respondent commented that physicists tend to have an air of superiority which suggests to all and sundry that they feel they represent the primary science and deserve some immediate recognition as such. However, unless there is some obvious and major physics-related content in a work position, then management is unlikely to fill a vacancy with someone just because he or she is a physicist.

Respondents were asked if they knew of any female physicists working in heavy industry in Australia and from the answers we now know there are at least two.

CAREER PATHS

Physicists in heavy industry can follow a number of career paths: as instrumentalists or analysts, in product or process development, in management, or in sales and marketing.

The instrumentalist path is largely a derivative of modern physics — lasers, X-rays, various electron spectroscopes, microcomputing, etc. The graduate student of physics is most likely to be familiar with at
least the theory of these instruments; have had extensive use of instruments; and be capable of seeing useful roles for instruments in new applications. The importance of good measurements to improving industrial processes can hardly be over-estimated and making and maintaining good instruments is a creative activity, in the right hands. To balance this, being tied to a particular instrument may severely limit future career options and lead to a 'machine driver' mentality.

Physicists moving into management may find they are no longer directly involved in scientific research. Two managerial respondents were concerned that because they had not practised any physics for many years their comments were of less relevance to the Committee's survey. This raised the dilemma that some of the best industrial researchers are lost to management — while industrial management requires good managerial skills combined with scientific ability.

Recently it has become obvious that there is a great need in industry for technically competent people in sales and marketing. Technical competence is required in sales support and demonstration and in systems development and purchasing. A question that physicists working in these areas must often face is: "why are you doing this instead of what you were trained for?" or in other words "why did you waste your time doing all that physics?".

SKILLS REQUIRED OF PHYSICISTS IN INDUSTRY

Industry requires science graduates, with a general technical background, capable of tackling a variety of technical problems. To some extent, the specific scientific field is irrelevant. What is important is the general discipline and analytical ability: simple principles, mathematics, and scientific modes of thought and reasoning. Moreover, working in industry requires a certain predisposition to see something come of one's work and the willingness to move outside one's area of expertise to see a project through to completion.

The analysis of processes, especially mathematical analysis, is one area where a physicist may be better prepared than other scientists. Although in principle, there is no reason why such analysis should be exclusive to physicists; in practice the 'feel' they develop for physical analysis is likely to be useful. The application of physical knowledge to processes or products is a creative activity and it appears so few people excel at it that its importance is not sufficiently recognised by many managers.

Compared with engineers, physicists have the advantage of a broader and yet more fundamental training. This training is of great benefit for applications where a theoretical framework must be established from first principles. The empirical approach of many engineers is not always the best or most appropriate way to tackle many of the problems encountered in heavy industry. For example, the measurement of product temperatures in a furnace or oven with intense local sources of heat is an important physical problem. Much of the knowledge required to solve this problem would have been presented to physicists in their undergraduate course-work.

Despite the advantages they may possess, or think they possess, physicists cannot afford to wait for industry to create the jobs they require. It is not sufficient for the physics community to inform industry of what physicists can do, and then to expect that industry will respond. Perhaps physicists should examine what industry wants and if physicists are not being readily employed in industry, academics need to ask why they are not providing the right 'physicist' product, properly labelled and marketed, rather than why the market is not opening up to consume their product.

Higher Degrees

Apparently higher degrees are a distinct advantage in industry where promotion involves heading a research team. Higher degrees are also of personal advantage in developing a sense of self-reliance and self-fulfilment. While the formal knowledge gained is not so important, a higher degree demonstrates ability to gain knowledge independently. In other ways, higher degrees are a disadvantage, by keeping the person out of the real world for too long, resulting in a narrowing of social contact and experience. The focus on individual effort in a highly specialised area may inhibit one's ability to deal with people and to give due weight to wider social issues and non-technical perspectives.

Management Courses in Physics Degrees

Several respondents felt that managerial-related segments were not required within degree courses and that such training was more appropriately conducted by the employer. Management skills were considered to be best learnt from within the organization. However, one respondent was highly critical of management practices in Australia and felt that management skills learnt within the industry or from carefully selected packages for industry merely reinforced poor management practice, especially in R&D.

JOB SATISFACTION

Industrial problems were viewed as neither more nor less challenging than academic research. Being a physicist in heavy industry appeared to be remarkably similar to being a physicist anywhere else. Big organizations, of whichever type, were reported to have a common face in areas such as the buildings, the pay and promotion structure, the administration, the support facilities, and the tea-room conversation.

Physicists in heavy industry tend to work with non-physicists rather than within a physics group. This is course is not unusual in Australia even for physics departments at universities where research efforts are often fragmented.

The biggest difference for research workers in industry, compared with government bodies and academia, is that if they are successful in their research, industrial people may see some change implemented in technology in a relatively short time. Heavy industry is more likely to employ researchers to understand and develop processes or products which already exist and are of some importance to the industry. This concentration on improving what already exists appears to be of greater concern, at least in established and mature industries, than immediate profit-making motives. It provides both the pleasure of rapid implementation and the limitations on what is readily achievable within a restricted design framework.

The hierarchical structure of large, heavy industries is a major problem. Division of the company into separate areas responsible for personnel, supply, sales, R&D, etc. may appear as a rational way to organise business; in practice, however, this method is often far from satisfactory. The separate pyramids of responsibility tend to develop protective hard shells, and when interaction is required it can be very difficult to achieve. Since much R&D, for example, involves interactions with other groups such as production and sales, the management structure often adversely influences both the rate at which work progresses and the difficulties of the task.

COMMENTS ON ACADEMIC RESEARCH

In Australia, a wide gulf exists between academic research and industrial R&D. Much of this gulf is fostered by attitudes on either side. Fortunately, there is a growing awareness of the problem and attempts are being made to bridge the gap. The following comments may indicate something of the industrial side.

Many academics, it was suggested, lack sufficient stimulation within their academic environment to formulate worthwhile problems — a task which is often more difficult than contributing to solutions. Many academics therefore could well benefit from the stimulation of non-academic environments. One area which is potentially full of intellectual stimulation is heavy industry, although industrialists themselves seldom recognize this. By offering their services for a consultancy fee academics may in fact have the degree of indebtedness reversed. Perhaps what is needed is for academics to receive payment only for results. It was suggested that young physicists might then find more opportunities for experience in industry. This approach contrasts with the supposed anti-intellectual or pratical bent of industrialists which has often been stressed by academicians as the reason for physicists not finding employment in industry.

Not all industries, of course, know how to approach universities, or academic institutions in general, and government research bodies. Indeed, they may lack the people, such as physicists, who can appreciate the usefulness of contacts with outside research organizations. The only options then open for them may be to import technology or simply to try to ignore problems which cannot be overcome on the factory floor.

In Australia we lack the small contract research organizations which abound in the US. Is it up to the universities, etc., to do something about this? It would require universities, and others, to adopt a policy of recruiting staff, who are enthusiastic towards interacting with industry, possibly through the creation of specialist positions.

CONCLUSION

The survey was clearly not a fact finding exercise designed to find answers to preset questions. It was simply an opportunity for physicists in heavy industry to present their points-of-view. Perhaps, the most controversial comment in the report concerned the marketing of physicists and physics to industry. This suggestion would involve significant change in both the public image of physicists and to the way physics is taught.

The Science Policy Committee wishes to thank those who contributed to the survey and extends an invitation to the general physics community to comment further on the issues raised.

R. Payling

Jobs for Physicists in 1984 — Much the same as 1983.

John R. Prescott, Physics Department, University of Adelaide.

From time to time friends and colleagues (and particularly my wife) ask me if I am not getting sick of surveying the employment scene for physicists in Australia. My stock answer is that it is not a bad way of passing the time between breakfast and coffee time on a Saturday morning, particularly when it is raining. In truth, the activity has become addictive and has become a new fascination. It also helps fill out the range of activities of the AIP Employment Committee.

This having been said, it must be admitted that the results of the exercise are acquiring a certain degree of predictability. Thus, the number of positions judged to be suitable for a graduate with a degree or diploma in physics or applied physics, and advertised each year in "The Australian" has been steady at about 680 since the surveys began in 1978. This has been so in spite of fluctuations in the job market generally, particularly the big slump of 1982-1983 when jobs of all types advertised in January 1983 were less than half of what they had been in January 1982 or have become in January 1985. There is no obvious reason why this should be so although by looking at the figures it is possible to see a "transfer" of advertisements from one category to another. For example, in 1982, when employment opportunities in commerce and industry fell by half at the depth of the recession, job opportunities in Defence and school teaching burgeoned so that the net effect was an almost constant total demand.

If one is to believe the media, 1984 was a year of recovery in the private sector and a year in which Governments, both Federal and State, were trying to contain their expenditure. This is generally borne out by the physics job figures. Commerce and Industry were still in the "non-sales" area although down in "sales". Geophysics jobs were well up and most of these were in the private sector. Taken overall, Government positions were about constant but there is clear evidence of the lack of Federal commitment to CSIRO and to Tertiary Education. This seems to be one of the areas in which they are intent on saving money, and public pronouncements from the relevant ministers do seem to support this view. From the point of view of the profession there is an essential balance to be maintained between pure and applied physics. This balance does not seem to be understood by those who hold the purse strings.

The Employment Committee felt constrained to write officially to the Minister for Education to contest her remarks at ANZAAS and on the ABC Science Show which appeared to decry "pure" research and to imply that advocates of a strong science manpower policy didn’t really know what they were talking about. It has to be regretfully recorded that the Minister did not deign to reply to our letter.

The results of the 1984 survey are summarised in the table, which also contains data for the previous four years. The breakdown by areas was discussed in detail in the first article in the series and will not be repeated here.

A new category has been introduced: "Defence". For the past three years it has accounted for around 20% of all Federal Government positions, with CSIRO and
ADVERTISED POSITIONS IN “THE AUSTRALIAN”

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

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"other" at 40% each. This classification has been taken back retroactively to 1982 in the table. This category has not been subdivided into “permanent” and “temporary” because, apart from one or two "contract" positions, jobs in this field are permanent. They are reputedly difficult to fill for two main reasons: a disindustrialisation of recent graduates to work in an environment where publication is likely to be infrequent and, because of the time the necessary security checks are complete, the better applicants have accepted a job elsewhere.

The slight increase in positions, both permanent and temporary, in CSIRO which was noted in 1983 has not been maintained and they are back to the average of the past five years. It is also evident that my last year’s cautious optimism about the Tertiary Education sector was misplaced. There is still a small handful of new tenured positions available (one University advertised three) but this area of employment has not yet turned the corner. Paradoxically, word-of-mouth has it that fields of applicants for tutorships are small.

Posts for school teachers are recorded if the advertisement explicitly specifies “physics”, although frequently it is combined with another speciality, e.g. junior science. These are teaching places in independent schools only and, as noted in the original survey, country schools still seem to be having difficulty finding suitable teachers. One school in a large country town advertised throughout the year. There were, in addition, advertisements from the Education Departments of N.S.W., S.A., N.T. and A.C.T. in both general and specific terms. For example, the S.A. Education Department advertised posts in three named country schools and four named city schools as well as for non-specific postings in both city and country. N.T. and N.S.W. are offering training with a paid allowance or scholarship. Nevertheless, the actual demand for physics teachers is down a bit this year, as it was last.

The only other feature of the table showing much of a change is in “Overseas” appointments which are boosted by a bumper crop of advertisements for post-doctoral fellowships for New Zealand Universities.

Geophysics is given a separate listing because in the Australian context it is usually grouped with the earth sciences. Such positions reflect the state of the economy for private industry and commerce and recovered to almost one hundred appointments. Among those were ten which might well have been listed elsewhere because of a degree in “physics” was specifically listed as a suitable background.
For the first time this year a summary of all jobs has been prepared and will be sent to Chairmen/Heads of Physics Departments in Universities and CAE's and to Careers Officers in those institutions. Any member of the Institute who would like a copy may get one by writing to the author.

In view of the quinquennial survey of enrolment trends in Physics by Jennings and de Laeter, some comment on the relation between supply and demand seems called for. As the Jennings and de Laeter survey shows, enrolment patterns have been changing over the past 17 years, with a relative decline in University third and fourth year enrolment but with an increase at CAE's. The total number of third and fourth year students has remained essentially constant, however, and the number of first-degree physics graduates in all categories is somewhere between 400 and 450 per year, of which about one quarter will go on to further professional studies in physics, or one third if we include teacher training. These proportions have changed little, if at all, over the past seven years. By and large, it is the latter groups to which the positions advertised in "The Australian" apply. As was made clear in the original survey, a large proportion of the jobs suitable for pass degree graduates (and some honours graduates) do not appear in the national press. For example, in 1984 there were about 40 positions advertised only in the Adelaide "Advertiser." With entries in the other main metropolitan newspapers, the total positions for physics graduates with some qualification in physics would be closer to 1000 i.e. about twice as many as appear in the "Australian" alone.

As in previous years, for about 150 positions a PhD in physics is explicitly stated or clearly implied. Curiously, nobody knows how many PhDs in physics graduated in 1984. The Commonwealth Statistician's figures are no longer helpful since they run two years in arrears, do not now clearly identify physics graduates and are rounded off to the nearest 10. The Employment Committees expects to address the defect shortly. In the meantime, Jennings and de Laeter estimate the figure to be about 50 per year, which is probably about right although perhaps on the high side. There is certainly a range of job opportunities for recent PhD's even if not always in their direct specialities. Among those noted, and presenting a real challenge were R & D positions in: fibre optics, papermaking, scientific instruments, lasers (of course), image processing, propellants, the built environment, fire hazards, monitoring of nuclear explosions, radar entomology (PhD in physics a stated requirement!), wool processing, polymer physics, to name only a fraction. Every one of these was a permanent position. As was pointed out last year, theoretical/mathematical physics is not the dead end it has been sometimes represented to be. In 1984 there were upwards of 50 positions, modelling in support of experimental work, for graduates with a theoretical training.

The report of the 1983 survey of the AIP Membership will shortly appear, authored by Ian Maclean. It shows that members of the Institute have a very low rate of unemployment and I believe that this is true for physics graduates generally. It is also noteworthy that an increasing number is now to be found in industry. The Employment Committee has long maintained that physicists have a larger place in private enterprise. It is encouraging to see that this is happening.

It is a pleasure to record the considerable assistance afforded by Tim Scholz, Karen Tusnady, Argyro Magoulis and Elaine Gregory in compiling the material for this survey.

References

Letter

Dear Sir,

It is good to see that the CSIRO is at last becoming interested in space research. What a pity it didn't interest itself in the subject a decade ago.

Then, Australia was the only country in the world to be opting out of "space". Woomera was phased out. The range was de-gutted and highly skilled people were being declared redundant. Never again would satellites be launched from Woomera.

Unfortunately we were run by the defence department and satellites were considered to be of no defence relevance. Out went upper atmosphere research, space research and anything else remotely resembling pure research. Out went the 26 meter antenna at Island Lagoon. It was sold to Marrickville metals for scrap at a price of $9000. What a boon that instrument would have been to the CSIRO now as an east west extension to the Australia telescope network.

I am sorry to say that, in my experience, scientific administration in Australia has been a total disaster. I suspect that science is not the only field to suffer from Canberra mal-administration if the fate of the dollar is anything to go by.

David S. Robertson.

Solar power for Ayers Rock resort

The new $150 million Yulara tourist resort at Ayers Rock is completed.

Located just outside the Uluru National Park, about 470km from Alice Springs, it will cater to 5200 visitors a day.

15% of the village's energy needs will be generated by solar power.

Most buildings have a double roof system with venting to reduce the load on air-conditioning. A network of solar collectors acting as a second roof for the suites produces hot water for the resort.

A striking feature of the design is in the sail-shape shade structures above many buildings in the village.

The sails will reduce the impact of summer heat and winter cold, control light penetration, provide shade and induce gentle breezes under calm conditions. By providing shade they will also reduce the air conditioning demand of the buildings by up to 40% compared to exposed surfaces.

All services to the resort, such as power generation and water supply, had to be developed. Ground water is supplied from the nearby Dunes Plains aquifer.

Television reception is via satellite through a parabolic dish earthstation.
Pure, Leading to Applied Research

by A.G. Klein, School of Physics, University of Melbourne, Parkville, Vic. 3052

Invited talk at the 3rd Applied Physics Conference, RMIT, Dec. 1984

The late Derek de Solla Price, physicist-turned-historian and sociologist of science at Yale, author of "Science since Babylon"; "Little Science, Big Science" and other similar titles, visited Australia in 1969 and gave a talk in which he addressed the general question: "What do scientists produce?" He came up with the following answers:

Scientists produce more scientists.

Scientists produce more science; and

Scientists produce wealth (i.e. tangible economic benefits).

He then applied it to the Australian scene and made it perfectly clear that Australian scientists have produced excellent scientists in both quality and quantity (Physicists are, after all, one of our leading export products). They have also produced excellent science, again both in quantity and quality, as measured by any yardstick. He saw, however, that in the production of direct economic benefits, "wealth", we do, by any objective standards, lag a long way behind comparable countries.

That was 15 years ago and it took that long for the sleepers in Canberra to awake. Most of us knew it all along, of course, and had perfectly good excuses: the industrial employment scene for physicists has never been outstanding and the technological revolution has not done much to improve it. Nevertheless, when our politicians now beat us over the head, we do have a prima facie case to answer because the facts, I fear, are still as De Solla Price stated them. What is the answer then? Are Australian scientists unwilling or incapable of producing wealth? No! Large numbers of them who have "drained their brains" are in fact producing wealth... but not for us here but overseas for their host countries. It is not the people, it is the climate here that is at fault, and I am in sympathy with attempts to modify the climate. But look at the clumsy way in which it is being tackled. Look at the fallacy: if we reduce the money available for producing more scientists and the money to produce more science, scientists will turn to producing more wealth, Q.E.D. The fallacy is obvious: budget cuts for pure research will not only lead to the production of fewer scientists and of less science but will also lead to scientists, especially young ones, producing nothing, through unemployment or inappropriate employment. The other measure is a more hopeful one: encourage industry to employ more scientists by offering attractive tax incentives for research. I applaud this election promise but at the same time would like to point up its dangers when taken in conjunction with budget cuts for pure research. The possible side-effects are that the people whose real business is pure research will join a Gadarene rush to do industrial work because that's where the money is going to be. The mixture could be very harmful for our pure research institutions and even more so in the case of the Universities.

The case for pure research at the CSIRO was admirably put by Dr Lewis Chadderton, Chief of the Division of Chemical Physics, in his recent talk on the ABC "Science Show", reprinted in the November 1984 issue of the Australian Physicist. The case for the Universities is hardly worth stating, it is so obvious. We are, after all, in the business of producing more scientists and of producing more science. That's what we are here for, and Lord knows we need more of both in this post-industrial age. Should we drop everything and start chasing the industrial dollar? The temptation is great! Should we resist? What is the answer? I do not presume to have the answer, but I do know of some. First of all, it is my observation that in places where scientists do produce direct wealth, such as the U.S.A., there is an entrepreneurial spirit which dominates the climate, with many fresh graduates eager to turn their PhD's into dollars. Perhaps we could do with a bit more of that spirit here. Secondly, and perhaps more importantly, it is also my observation, again in places where scientists' production of direct wealth is much greater than here, that instead of the scientists chasing after the crumbs from the tables of industry it is actually the other way around. Industrialists, especially from the so-called high tech sector, are actively sniffing around for the bright new ideas that abound in the laboratories at M.I.T., Stanford, etc.

Well, the bright ideas abound in the laboratories of the University of Melbourne too (inter alia), as I hope to show you soon. In fact, after this lengthy preamble I will get down to the real business of conferences such as this, namely to advertise the product... in this case the products of our students. I propose to describe a number of applied physics projects carried out by people in the Particles and Fields Group at Melbourne University, supervised by Geoff Opat, Al Cimmino and myself, which all have in common that they began in the context of the purest of pure fundamental physics with motivations impinging on the foundations of quantum mechanics, the nature of elementary particles, gravitation and inertia, and other such long-haired stuff. We don't apologise for working on fundamental problems... on the contrary, someone's got to do it, and where else if not at the University? And if no one attacks fundamental questions there will be nothing new to develop in the future.

So let me tell you a little about the work that we do and the applied physics that it has led to. Most of the developments that I will speak about are the subject of 5 contributed papers at this conference and I will therefore be very brief and general; please go along to the other sessions for detailed expositions.

One of the research programmes in our group concerns the behaviour of electrons in solids under the influence of gravity, or equivalently, inertia. One of the simple questions that we ask is: What happens to the electrons in a piece of metal when you shake it? The experimental answers are as intriguing as they are difficult to obtain. Tim Davis and Gareth Moorhead are now reliably measuring signals of the order of tens of nanovolts — but it wasn't easy! Along the way, apart from becoming very good at making low-noise measurements, Tim Davis also became very good at sending ultrasonic waves up and down metal rods. When it came to my attention that people might be interested in measuring the elastic constants of Partially Stabilized Zirconia — the new wonder ceramic developed by the CSIRO Division of Materials Science — especially at high temperatures, I thought it obvious that an ultrasonic method would be suitable for probing a specimen inside a furnace. After all, by measuring the speed of ultrasound in a material one can easily obtain

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its elastic modulus. Tim Davies and Al Cimmyno proceeded to prove me right... but there was a twist to it. With a very cunning pulse-echo method they showed that one can obtain not only Young’s modulus but also the shear modulus... and hence the Poisson’s ratio... and hence the Young’s modulus. When we proved to them that we can produce the goods, the people at CSIRO kindly built and lent us a furnace and the people at NITRAN made us a suitable specimen of PSZ. A surprise turned up almost as soon as we received the specimen of PSZ and started taking measurements at room temperature: Poisson’s ratio for PSZ, unlike most other ceramics which have a value around 0.35, is up around 0.25... more like that of a metal! We feel that this is a significant piece of information but we have not yet got to the bottom of it... apart from checking and re-checking our measurements. With the furnace in place and the system set up, Mark Grigg obtained excellent data for all the elastic constants, from room temperature up to 1100°C... which we hope is valuable engineering information on PSZ. At the same time, Mark Grigg was able to measure the attenuation of the ultrasonic waves in the material, for both compressional and shear waves, as a function of temperature. The information obtained is extremely interesting and reflects the phase transformations that are taking place inside the material. This, in turn, feeds back into the fundamental materials science aspect of the behaviour of the material and is the subject of Dr. Piggott’s studies. Meanwhile, if you want to know the elastic constants of any other ceramics, rocks or any other solids, for that matter, as a function of temperature... please come and see us!

Going back to the fundamental experiment with the metal rods, another problem that we had was the measurement of the vibration amplitude along the rod, to fairly good accuracy. We worked with inductive and capacitive transducers but eventually Mark Cimmyno and Tim Davis hit upon a simple optical technique which shows great promise as another piece of instrumental spin-off.

As you can well imagine, we also had great trouble with stray magnetic fields... remember that we are trying to measure nanovolts in a vibrating rod. Adequate multiple mumetal shields would cost a fortune! So, Gareth Moorhead designed a set of Helmholtz coils for nulling the magnetic field and a set of home-built fluxgate magnetometers to measure the residual field in the middle. It is but a simple step... or a stroke of inspiration, if you like... to close the loop between the magnetometers and the current drive to the Helmholtz coils. The resulting feedback arrangement not only nulls out the Earth’s magnetic field but also tracks and cancels stray fields at 50 and 100Hz, thereby producing field-free regions over a substantial volume, down to less than a milligauss. Worldwide sale of mumetal and other magnetic shields testifies to the need for a commercial version of our “active” magnetic shield. Where should we go from here?

Another aspect of our project on the electromagnetic properties of accelerated matter concerns the measurement of the shifts of the Fermi levels in metals as a function of temperature and of applied stress. Consequently, Frank Rossi and Terry Harders have devised very cunning methods for measuring contact potentials as a function of stress and temperature, respectively; their work, together with its fundamental motivation, will be described by Dr. Harders a little later in the programme. I simply wish to point out the potentially wider applicability of their techniques to more applied areas of surface science.

Lastly, on this subject, our experiments will, eventually, be extended to superconductors to study the behaviour of Cooper pairs under acceleration. To this end, Tim Darling is working with Josephson junctions and SQUIDs. In collaboration with RMIT, he is attempting to produce devices by ion-implantation... a subject of considerable technological interest. He will describe his work in another contribution at this conference.

The other major projects in our research group are on Neutron Optics and Molecular Optics, a significant aspect of which is to do with tests of fundamental propositions in Quantum Mechanics. Geoff Opat and I have given several talks on this subject in various places; on this occasion I simply wish to expose some of the applied physics spin-offs that have resulted from this work. In attempting to invent a new type of neutron interferometer and an interferometer for exhibiting macroscopic interference with a beam of slow molecules, a project which is in progress, our group has come up with a new and very simple type of optical interferometer which has the virtue that it works with white light as well as monochromatic light and, as an added bonus, it has the extraordinary property that it is almost un-mis-alignable! This device was described and demonstrated at the Optical Physics Conference earlier this year, and it created quite a bit of interest. If I have the time I will give you a little bit more about it because it is not presented again at this conference. As invented by Geoff Opat and myself, it began with three diffraction gratings: optical elements which are realisable for neutrons and for molecules. It was rapidly reduced to two reflection gratings, rather than three transmission gratings, and we thought it had a good chance of working, so we began and borrowed two good gratings from CSIRO Chemical Physics. Stephen Wark built it and tested it and was reporting on its performance at a group meeting when Bill Hamilton had a brilliant idea: You don’t need two gratings: a single grating plus a mirror would do! The grating sees a reflection of itself in the mirror and the two are, naturally, un-mis-alignably parallel. Well, it works like a charm producing fringes over a very wide band of wavelengths... white light, as I said... a feature which is very important for the work on neutrons and molecules. At the same time, however, it is bound to have great potential in metrology, or as an optical transducer, for example, for mass measurement. Such a property which changes the refractive index of a medium. Geoff Opat has just completed the detailed analysis of this interferometer and we can now begin to think of practical applications (other than for neutrons and molecules). Suggestions are welcome!

Bill Hamilton’s other experiment is to demonstrate neutron diffraction from Surface Acoustic Waves. To this end, he has built SAW devices from quartz and from Lithium Niobate, and in order to characterise their performance he has built a Laser Probe for measuring the amplitude of the surface waves on such devices. He will report on this work later in the conference.

Finally, let me talk about another piece of serendipity, with potential applications. I had occasion, a few years ago, to make a transparency of a set of random dots. The copy of the transparency, superimposed on the original, shows quite a startling visual effect: Great swirling circles appear, centred on the instantaneous centre of rotation which characterises the displacement of the copy with respect to the original. I sent this in to the “Scientific American” as a piece of idle curiosity a few years ago and Jean Walker ran it in her column. A few months later, blow me down, a facial surgeon at the Massachusetts Dental Hospital found a use for this idle curiosity. In planning facial surgery to move the lower jaw with respect to the skull, Dr. Seldin takes
two X-ray photos and superimposes my random dots on them, initially in perfect alignment. He then moves the pictures about, to reach the desired, new position of the lower jaw and bingo! The instant centre of rotation appears immediately, telling him where he has to cut bone.

So, here was something totally useless turned into something useful in a wholly unexpected way in a wholly unrelated field. But this was not the end of it. At the 1st Applied Physics Conference at RMIT two years ago, we heard a paper by Gordon Trup and Robin Turner of Monash University, together with Rod Winnington (now at Melbourne University Chemical Engineering) developed an ingenious method for measuring fluid flow velocity by a laser speckle method. If a flowing fluid is seeded with light scattering centres and flash-photographed, you get a pattern of random dots. A double or multiple flash photograph of it will look a lot like my random double dot pattern. If you now shine a laser beam through the photograph and look in the plane of the Fraunhofer diffraction pattern you will see a speckle pattern crossed by interference fringes, just like in Young's experiment. The fringes are the same as those which would result from just two point sources; where we simply have a large number of point pairs whose interference patterns add incoherently. The fringe spacing is therefore inversely proportional to the spacing of the dots and hence to the velocity of the fluid, i.e. the distance moved between the two flashes. Furthermore, the direction of the fringes gives the normal to the direction of the flow.

Now, as I said, when you look at a double exposure photograph of a fluid flow situation, seeded with light scatterers, you get a pattern very much like my pattern of random dots in which the rotation of the fluid is very clearly apparent. How is the rotation expressed in the diffraction pattern of such a picture? Could one use such Fourier Optics techniques for measuring not only the velocity but also the vorticity of the fluid? (This is proportional to the local rotation in the fluid and is actually the vector potential for the velocity field, a very important quantity in fluid mechanics). Well, we worked out the Fourier Transform of a rotated random pattern and deducted that in 2-dimensional fluid flow, at least, it should be possible to extract such information. Computer simulations by Tim Darling and actual experiments on a rotating bucket of water, by Helen Beggs, have shown that the method is indeed feasible, though it has its limitations. It turns out that you still get Young's fringes but their visibility envelope is a 2-D Bessel Function with elliptical boundaries. For no rotation the fringes would extend indefinitely; for pure rotation they have a circular boundary whose radius is inversely related to the angle of rotation (i.e. the vorticity). In the general case, shear is present, in addition to rotation, and one gets an elliptical boundary. The major and minor axes of the ellipse give information about the shear as well as about the angle of rotation in 2-dimensional fluid flow. The work of Trup, Turner and Winnington is currently being used in studies of Newtonian fluid flow. We hope that our extension of the method may also find application.

I hope that I have given ample illustration of how pure leads to applied physics, in the microcosm of our Laboratory. The general conclusion is admirably summarised by Dr Chaddock who said: "Pure research leads to applied research, which leads to innovation and invention, which leads to high technology, industry, export markets, and job creation. The line of flow is clean, continuous, and incontestable." But I do wish the line of flow, especially between innovation and industry, were really clean and continuous, incontestable though it may be.

New Attack on Sickle Cell Disease

Clinical trials are expected to follow the discovery that a commonly used drug may be able to control the crippling and sometimes fatal sickle cell anaemia.

The disease is an inherited one that was originally prevalent only in malarial regions of Africa, but it is now also frequent in Britain and the United States.

Sickle cell anaemia is caused by changes in one of the genes of the protein called haemoglobin which is in red blood cells and carries oxygen from the lungs to body tissue. The result of these changes is that the haemoglobin gels in the red cells when they give up their oxygen, and the gelled cells then obstruct the circulation of blood in many organs.

Most drugs perform their function by binding to proteins, and scientists from the UK Medical Research Council's molecular biology laboratory in Cambridge and the University of Pittsburgh in the United States have been experimenting with computer graphics to see how this occurs.

Until now only in two instances have researchers actually seen how the binding takes place, but during these studies, former chemistry Nobel prize winner, Dr Max Perutz, and his colleagues Dr Giulio Ferri and Professor Don Abraham discovered that two common drugs combined naturally with haemoglobin. One inhibited the gelling of the protein while the other promoted it. The drug that stopped the gelling is an acid that is normally used to increase the secretion of urine.

Once the possible new role for the drug was seen, the Anglo-US team set about finding out the structure of the combined protein and drug. Using X-ray analysis the scientists found that the drug molecules were only a fraction of the size of the protein molecule; when they bind, the drug molecules find themselves a "nest" that exactly fits their size and shape.

The binding of the gel-resisting drug affects the oxygen carrying function of the protein by raising its affinity for oxygen, just as the gel promoting drug lowers it. Dr Perutz said: "This discovery may be the starting point for the development of new drugs designed to modify the oxygen affinity of haemoglobin after heart attacks, blood transfusions or when oxygen is scarce."

SAFETY NOTICE

Human contact between ground and the metal parts of a vacuum chamber can be dangerous if the metal is not grounded, and if an ionization gauge is operating in the chamber at pressures of 1 pascal (7x10^-4 torr) or higher. Lethal electrical shock can possibly occur if all of these conditions are present. Common grounding of the metal parts of the vacuum chamber and of the ionization gauge controller chassis removes this danger.

from Granville-Phillips

The Australian Physicist, Vol. 22, May 1985 — Page 141
People

Physicist in chair

Professor Fred Smith of Physics has been elected chairman of the committee putting together the constitution for a proposed Federation of Australian Scientific and Technological Societies.

A meeting of the societies in Canberra last month decided to form the body to lobby government, increase the profile of research and development in the community and provide a forum where serious crosswalk between disciplines can occur.

"There is no doubt that as a community science and technology society members have been singularly unsuccessful at influencing government and convincing the media and the public of their importance," Professor Smith said.

Monash Reporter, May 8, 1985

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Charles Chree Medal and Prize

Dr A E Gill of Oxford University has been awarded the Charles Chree Medal and Prize for his outstanding contributions to geophysical fluid dynamics.

Adrian Edmund Gill was born in Melbourne, Australia, in 1937 and obtained his BA (Hons) and MA from the university there in 1959 and 1960 respectively. He then came to England to work for his PhD at Cambridge, studying the stability of axisymmetric flows, before crossing the Atlantic to work as a Research Associate at the Massachusetts Institute of Technology for a year. Whilst there he demonstrated mathematically the mechanism by which instabilities develop in pipes and did pioneering work on the phenomenon now known as over-reflection in hypersonic flows.

He returned to Cambridge in 1964, where he was, until 1978, Assistant Director of Research in Dynamical Oceanography. For the last 5½ years of his time at Cambridge he was both Royal Society Esso Senior Research Fellow in the Department of Applied Mathematics and Theoretical Physics and a Fellow of Darwin College. During his 20 years there he built up a major successful, internationally renowned group in ocean modelling with support from the Ministry of Defence (Navy), the NERC, the EEC, the Royal Society and the US Office of Naval Research. He also established links with all the leading institutions in the world in this field by spending periods of leave at establishments in the USA, South Africa and Australia and through the sabbatical visits of eminent oceanographers to Cambridge. Dr Gill has also had strong links with the Meteorological Office throughout his career.

In 1984 he moved to the Hooke Institute at the Department of Atmospheric Physics of the University of Oxford (where he is now a Fellow of St Cross College). The Hooke Institute is jointly supported by the Meteorological Office, NERC and the University. Dr Gill is chairman of the scientific steering group of the TOGA - Tropical Ocean and Global Atmosphere - programme of the World Climate Research Programme, for which coupled atmosphere-ocean numerical models are to be developed at the Hooke Institute. The group involved has been built up from past members of Dr Gill's group in Cambridge.

Adrian Gill is internationally recognised for his work in geophysical fluid dynamics, having made outstanding theoretical contributions to a wide range of topics, including the stability of pipe flow, thermal convection, the circulation of the Southern Ocean, seasonal variability of the ocean, waves in rotating fluids, wind-induced upwelling, coastal currents and sea-level changes and coastaly-trapped waves in the atmosphere. He is particularly effective in the way he is able to interpret observations and guide the activities of observational work.

During the last few years he has set up some simple models which throw light on the El Nino phenomenon, both in its atmospheric and oceanographic components, and has taken a leading role in organising international effort in research associated with the El Nino. He is also the author of a substantial book, Atmospheric Ocean Dynamics, published in 1982, and has been for the last eight years editor to Ocean Modelling, a popular informal newsletter circulated to some 600 interested people worldwide.

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Charles Vernon Boys Prize

Dr D J Smith of Arizona State University has been awarded the Charles Vernon Boys Prize for his achievements in commissioning the Cambridge 600kV high resolution electron microscope and applying it to the elucidation of the atomic structure of materials.

David John Smith obtained his BSc and PhD degrees at the University of Melbourne. He went to the Cavendish Laboratory in 1976 to work as a postdoctoral assistant with Dr V E Cossett and Dr W C Nixon on the completion and commissioning of the 600 kV high resolution electron microscope. In late 1978 he was made a Senior Research Associate and appointed Acting Director of the Cambridge University High Resolution Electron Microscope; in 1980, he became its Director.

Bringing this 600 kV microscope into full operation...
has been Dr Smith's almost single-handed achievement. When he joined the unit in 1976 the instrument was in the final stages of construction — a collaboration between the Engineering Department and the Caven- 
dish Laboratory. Dr Smith participated in the final stages of building and testing and, as Director, took on the task of commissioning it and exploring its applications. After paying detailed attention to the various environmental 
hazards, particularly mechanical vibration and stray fields, he attained the resolution of 1.7 Å consistently. With the cooperation of specialist scientists, both in Cambridge and from outside, he has been making use 
of this performance, which extends to the direct 
observation of many types of atoms, in studies of catalysis, crystal growth, dislocations in metals and 
semiconductors. This exploitation of an atomic resolu-
tion has so far resulted in nearly 100 papers, apart from a 
number of improvements to the microscope and 
reviews of the subject. In fact David Smith has been 
largely responsible for keeping this country in the 
forefront of high resolution electron microscopy. 

Since September 1984 Dr Smith has been Associate 
Professor at the Center for Solid State Science of 
Arizona State University, where he is continuing research into fundamental developments of high resolu-
tion electron microscopy, as well as applications to the 
characterisation of structural defects, particularly in the 
areas of surfaces, semi-conductors and nonstoichiometric oxides. Dr Smith was elected a Fellow of The 
Institute of Physics in 1981.

Ninth AIP Condensed Matter Physics Meeting

The annual meeting of the Australian solid state 
community was held at Wagga Wagga from 6-8th 
February with a title change (from Solid State Physics 
Meeting) being the largest departure from the well-tried 
and very successful format of previous years. Wagga 
Wagga turned on its usual weather with temperatures in the mid-thirties which in my view makes an enormous 
contribution to the informal, relaxed and friendly 
atmosphere of these meetings.

The 105 participants included 10 overseas visitors. For many of them it was their first look at Australia 
outside the large cities and being woken by the outback 
alarm clock — a flock of screeching galahs at 6.30 a.m.

The thirteen invited talks covered a wide spectrum of interests. L.F. Mollenauer (AT & T Bell Labs) opened 
new ground for most of the participants with his description of the recently invented soliton laser, which 
is capable of producing 100 fs sec IR pulses in its normal 
form or a few tens of fs by compressing the pulse in an 
optical fibre. The laser theme was continued by R.M. 
Macfarlane (IBM, San Jose) who surveyed the 
technique, uses and limitations of optical hole burning 
spectroscopy.

Z.H. Stachurski (Monash) brought some new twists 
to the theme of strain — stress relations with his 
description of the behaviour of amorphous ductile 
polymers, which required some rethiking for those 
used to dislocation theory as the new way to describe 
strain. The modern theory of chaos was used by H. 
Hasegawa (Kyoto) to describe the transition of the 
hydrogen-like energy levels into the Landau levels under 
a continuous change of magnetic field strength.

In the first of two x-ray talks Grant Moss (Melbourne) 
reviewed the recent uses of x-ray diffraction electron 
density maps to determine electrostatic potentials, 
electric field gradients and the electrostatic component of 
molecular interaction energies. The use of total 
external reflection of x-rays to study surfaces was 
described by F.H. Cooks (Duke) with particular 
application to the chemical composition of amorphous 
thin films. E.C. Fawcett (Toronto) then discussed the 
interpretation of magnetovolume changes in weak 
itinerant magnets.

Even the experimentalists came away enlightened 
from the clear description of the local density functional 
method given by K. Kunc (C.N.R.S) and its application 
both static and dynamic properties of crystals. The 
recent tests on the use of SYNROC to immobilise high 
level nuclear waste were described by K.F.D. Reeve 
(A.A.E.C.), leading up to the expected commissioning 
of a full scale demonstration plant at the end of 1985.

In an innovative experimental arrangement making 
 optimum use of modern computerized data — logging 
methods, R.B. Roberts (CSIRO Applied Physics) 
described how to measure five thermal and electrical 
properties of metals from 1000 — 3000°C — all in one 
second. Thousands of measurements are taken in this 
time as the sample is self-heated by a large current, a 
system which left many of the audience contemplating 
what ingenious means they could devise to reduce their 
own particular experiments to a similar time scale. C.J. 
Howard A.A.E.C. Applied Physics) returned to us better 
documented territory with a review of the applications 
of neutron scattering to structural phase transitions such 
as those in strontium titanate and potassium dihydrogen 
phosphate.

The nuclear orientation measurement of nuclear 
relaxation times of dilute impurities in ferromagnetic 
hastelloy was described by E. Kein (Free University, Berlin) 
with emphasis on the problems of understanding 
the field dependence of spin — lattice relaxation time in 
intermediate fields of 0.15 T < B < 1 T. The final 
invited talk by J.T.A. Pollock (CSIRO Chemical 
Physics) covered the new applications of ion 
implantation techniques in improving the surface 
characteristics of materials particularly in the area of 
wear resistance.

The remaining 80 contributed papers covered an 
impressively-wide variety of topics and were mainly 
presented in well-attended poster sessions, occasionally 
enlivened by the nearby industrious carpenters. Prizes 
were awarded for the best three posters on each day. 
The Wagga SSP (now CMP) meetings are among the 
very few conferences at which posters get a good airing, 
with a 24 hour "up-time" and prescribed times for author 
attendance with no scheduled lectures. I wish more 
conferences would adopt these allowances.

After six Australian SSP Conferences in the series (2 
have been in New Zealand) the job of organizing this 
conference returned to the original grouping from 
CSIRO Division of Applied Physics and we are grateful 
to the committee headed by Guy White (Chairman), 
Arthur Little (Secretary) and Ron Trainsh (Treasurer) 
for another very successful conference. It will be on 
again next year, same week, same venue with the same 
sociable mixture of physics discussions, swimming, 
jogging, squash, tennis, etc all helped by the The College 
wines so we hope to welcome both "the regulars" and 
a new selection of visitors and younger physicists. 
Further information may be obtained from Dr Trevor 
Finlayson, Department of Physics, Monash University, 
Clayton, Vic., 3168.

J.D. Cashion

The Australian Physicist, Vol. 22, May 1985 — Page 143
Opportunities for Post-Graduate Studies and Research in Physics

Professor Whitehead asked all Heads of Departments to supply information on this topic for publication in Aust. Phys. It is hoped that next year’s coverage will be fuller.

It is sometimes difficult to know what areas of research are being undertaken at any particular institution. As a regular annual feature, it is hoped that the Australian Physicist will publish a list of research areas in the various Universities and Institutes of Technology. The following list, incomplete though it be, may be of use.

Department of Physics
La Trobe University,
Bundoora, Victoria 3083
DIVISION OF ELECTRON PHYSICS
(Head: Dr J.D. Riley)


DIVISION OF THEORETICAL AND SPACE PHYSICS
(Head: Professor K.D. Cole)


Studies relating to the properties of the ionosphere and magnetosphere using radio and optical techniques. Auroral physics. Solar-terrestrial relations. The division of theoretical and space physics operates a field station in Kilmore Shire and encourages collaborative projects with outside agencies. Studies of atom-ion interactions are conducted in the division’s laboratories.

Department of Physics and Theoretical Physics
Faculty of Science
The Australian National University
P.O. Box 4, Canberra, ACT 2601
(Head: Professor S. Hinds)

The aim of the laser spectroscopy group is to study a variety of phenomena concerning the interaction of narrow beam laser light with atoms. It encompasses general high resolution spectroscopy using modern sub-Doppler methods, through the interaction of a strong radiation field tuned close to resonance with atomic transitions, to non-linear optics.

The shock physics group is concerned with using the unique free-piston shock tube facilities to study the thermodynamics of hypervelocity vehicles through the earth’s and other planetary atmospheres (currently work is proceeding on an earth orbital transfer vehicle) and the propagation of high speed shock waves, particularly related to Mach reflection and the stability of shock waves and relaxation fronts.

The nuclear structure research group carries out experimental investigations of the properties of atomic nuclei for comparison with the predictions of theoretical nuclear models. The group collaborates with physicists in the Department of Nuclear Physics, of the Institute of Advanced Studies (ANU), and uses their facilities.

Department of Physics
University of Queensland,
St. Lucia, Queensland 4067
(Head: Professor J.D. Whitehead)

Geophysics, testing Newton’s law of gravity, thermal properties of the earth, earthquake prediction, magnetotelluric studies. Ionospheric physics, E and F region disturbances using HF techniques and satellite signal scintillations. IR and sub-mm laser physics, non-linear optics. Microwave spectroscopy, molecular relaxation processes. Solid state physics, X-ray and neutron crystallography, phase transformations.

Astrophysics, cosmic abundance, experimental determination of relevant atomic properties. Theoretical quantum optics, interaction of light with atomic and molecular systems. Environmental physics, water flow in rivers, ocean waves.

Department of Physics
University of Western Australia
Nedlands WA 6009
(Head: Professor J.F. Williams)

EXPERIMENTAL

Experimental research focuses on atomic and gravitational physics. Atomic Physics includes electron, atom and ion beams spectroscopies and scattering, x-ray and laser spectroscopy. The production and detection of spin-polarized electrons, as well as crystallography and atomic structure studies. The gravitational physics research includes gravitational radiation detectors, gravimetry and the development of ultra-sensitive measurement methods. Both areas include solid state, high vacuum and cryogenic physics, digital electronics and computer automation and other significant modern high technology areas.

THEORETICAL

Theoretical research includes phase transitions and critical phenomena, cosmic electrodynamics and high energy physics.

The department has excellent electronic and mechanical workshops, helium liquefier and computing facilities. There are 16 academic staff, about 20 technical staff and typically 20 postgraduates and 12 honours students.
BOOKS

Book Reviews

Reviewed by R. Delbourgo, Department of Physics, University of Tasmania.

This is the seventh book in the Cambridge Monograph series and the fourth devoted to the gravitational field in some form or another. It is a worthy addition to the collection and serious students (and experts too) in the subject of the impact of quantum theory on general relativity should not be without it. I am not certain that people who work in other areas of field theory need acquire this text as the material is rather specialised. However they should get the library to order a copy as I feel that this book is destined to become a standard reference in the particular topic it deals with, for some time to come.

The material is concerned, precisely as the title says, with the influence of quantised fields on the structure of space-time, the gravitational field being treated classically and never quantised. The greater part of the book deals with the effect on the energy-momentum tensor of the matter-gravity interaction through the inductive and added curvature terms (of the type \( R^\mu \) as a consequence of 1-loop quantum corrections. Except for the very last chapter, the nonlinear interactions of the matter fields among one another are neglected. Also, for the most part, the authors are concerned with scalar fields; on the odd occasion, where it is important, they describe the extension of their work to spinor fields and to the electromagnetic case.

There are many technicalities in this subject and the authors take great pains not to shirk them — hence my claim that the book will appeal to a limited readership. Nonetheless there are several topics of great interest such as particle creation near black holes and the appearance of thermal backgrounds for accelerated observers, where the authors speak with great clarity and authority. I recommend particularly the last part of Chapter 3 and Section 8.2 for those people who are unwilling to plough through all the mathematics (which is fearsome at times). The reference list is extensive and should prove useful to people who wish to delve into the intricacies of the subject. I might mention that Osborne and Jack have recently generalised the authors' compilation to include other matter fields, gauge fields especially, and have worked out the quantum corrections to order \( \hbar \).

I was grateful to Birell and Davies that they adopt the notation to which I have become accustomed (dimensionless metric and natural units). Their introduction is a splendid summary of quantum field theory as far as the authors require it for the subsequent development. The most difficult, and by far the longest, chapter deals with various renormalisation schemes and is useful in its own right. So are the formulae detailing the structure of the corrections with their sundry coefficients.

As far as this book is not for the faint-hearted. If you are courageous enough to attempt to study it, your efforts will be amply rewarded. It should be said that there is no other text which deals with the same subject matter.

Reviewed by T. Thomas, Department of Physics, The University of Adelaide.

It has taken rather a long time to produce the proceedings of this meeting which was held at Lahnstein in June 1981. For this reason some of the discussion of "new" experimental results is out of date. Nevertheless, there is considerable material in this immense volume (over 900 pages) which will not fade with time, and which makes it a compulsory purchase for any university library. With a price tag of $110 not many individuals will buy it.

Amongst the highlights of the book are the opening remarks of Greiner himself, laying out the vast field of heavy ion collisions as a method to make supercritical fields. However, it must be mentioned that as well as dealing with electromagnetic interactions the volume includes a smaller amount on pion condensation and strong gravitational fields. Particularly in the former, his historical survey is patchy — for example, the work of Oppenheimer and Volkoff is not mentioned. Moreover, the omission of any reference to the study of Gamow-Teller resonances and the quenching of \( g_4 \) in heavy nuclei (suggested by M. Ericson, spelt Erickson in the text) makes this section less valuable.

The summaries of the theoretical aspects by Biedenharn and particularly the experimental aspects by Greenberg are very valuable. Of the lectures which I read, the following were the most valuable: Ericson on QED; Muller on QED in strong fields; Bohm on electroweak tests at PETRA; Rafelski on particle condensates; Baker on the problem of quark confinement in QCD and Faessler on the absence of pion condensation. However this is by no means an unbiased selection. It omits over 300 pages of fairly detailed treatment of experimental techniques, which I was not fit to evaluate, but which I am sure would be useful reference material for those working in low energy heavy ion physics.

Reviewed by M. Andrews, Department of Physics and Theoretical Physics, The Faculties, The Australian National University.

This strange book is essentially a textbook on elementary quantum mechanics. It therefore competes with hundreds of such texts and naturally must claim some special characteristics to distinguish it from the mob; in this case the special claim is to introduce quantum mechanics via considerations of symmetry. This is indeed a laudable aim and I believe there would be room for a text which achieved this. Unfortunately this book does not.

The usual applications of symmetry to quantum mechanics do not appear. Duffey claims, however, to use symmetry ideas to derive the plane-wave form of the wavefunction for free particles of definite momentum, before introducing Schrodinger's equation. To quote an example of the arguments used:

"For the pure motion we are studying, there is no reason to expect any part of \( \Psi \) to exert a different effect on \( d\psi \) than any other equivalent part. The simplest way to incorporate this symmetry is to make..."
dψ homogeneously linear in ψ.

I find these arguments contrived and unpersuasive. Later he uses similar, equally unconvincing, reasoning for the form of the wavefunction for a freely rotating system. Eventually he gives the useful sort of "derivation" of Schrödinger's equation and applies it to the usual range of elementary systems. Thus the scope of the book is fairly conventional but I find his discussions often obscure and sometimes false or misleading.

On the positive side the book is well set and has very few misprints. It contains extensive sets of discussion questions and problems (usually rather trivial) with answers where appropriate. It also contains at the end of each chapter a useful list of references to relevant papers (thankfully including titles) mostly from the American Journal of Physics.

In summary, this book is too expensive for use as a student text and, in my opinion, is too unclear and unsound even for that use or as a reference work.


Reviewed by G.I. Opat, School of Physics, The University of Melbourne.

The increasing use of quantum optics and electronic technology, and its associated atomic molecular and solid state physics, requires that an increasing audience of physicists, engineers and applied mathematicians be familiar with the elements of quantum electrodynamics. An appropriate literature is emerging.

This small book on quantum electrodynamics gives a reasonably standard account of the theory, following a short historical introduction. A full chapter is devoted to symmetries and conservation laws. The style of the book is mathematically formal, and the author pays considerable attention to elegance.

A special feature of the book is the attention it pays to line integral representation of the vector and scalar potentials and their gauge transformations. This is done to facilitate the formulation in Chap. 7 of "Path-dependent electrodynamics", a formalism to which the author has contributed, and which adapts the theory of typical non-relativistic applications, such as are found in atomic physics.

This book is the experimental side of the subject, and does not follow the formalism to the cutting face of applications. It is well written, has copious references, and has very few errors. It will appeal principally to applied mathematicians and mathematical physicists, who will be able to acquire a knowledge of QED without having to digest large tomes on the subject.


Reviewed by R.A. Creelman, School of Earth Sciences, Macquarie University.

Minoru Ozima in his preface to the English edition of this book thanks his colleague Judy Wakabayashi for converting "a language suited to the heart to a language suited to the mind". The final product still retains the delicacy of the original Japanese, so is a delight to read.

"The Earth, its birth and growth" is an unusual book because in eight chapters it reviews the evidence and presents the hypotheses of Earth evolution very much from the strict discipline of physics. Historical geology normally bares the mark of the more liberal natural sciences, so to read the alternate is both refreshing and disturbing.

It is refreshing because here is one of the few clear, precise and readily available accounts of isotopic methodology and interpretations as applied to geochronology and the chemical evolution of the earths crust. It is disturbing because there are a number of topics presented with a ring of certainty that I, as an earth scientist, would not dare to use. The early history of life is the prime example. The author relies very much on Preston Cloud's research and ideas, but people in this field are not sure that Preston Cloud has the story correct. A body of contrary literature is emerging that is seriously complicating the problem.

On reflection it must be conceded that the physicist deals with less complex, one might say more ideal, problems and situations, so what is known is known with greater certainty. The earth scientist, particularly the geologist, is hampered by both the scale of the problem and the simple fact that the time factor in experiments cannot be matched the time the earth has existed. "Knowledge" is therefore held with much less certainty. Minoru Ozima devotes a short paragraph to these questions.

Summarizing: Read this book as an example of good, clear, writing. A must for those who might contemplate applying their physics to problems in the earth sciences.


Reviewed by A.F. Collings, CSIRO Division of Applied Physics, Lindfield NSW.

This is hardly a book that many physicists will hurry out to buy. More's the pity! The author has produced an excellent review and critical state of the art in a most relevant area and indicates that a number of interesting problems in physics remain to be resolved.

Oka has given a direct, lucid and self-contained treatment of his subject, one that is unpretentious almost to an extreme. He has resisted the temptation to "pad out" the book with undue experimental detail, statistical surveys of blood properties and description of diseases of which blood flow has clinical implications (I invite comparison with recent works in this area). There is a good list of references which will permit the interested reader to pursue any specific interest.

One might question the cost of such a small book, but it might be worth paying more to have the extraneous padding removed from many specialist books.

COMBINED REVIEW


Reviewed by P. Fisher, Department of Physics, The University of Wollongong.

The excellent series of Books to which these belong is edited by M. Cardona, P. Fulde and H.-J. Queisser of the Max-Planck Institut in Stuttgart.

The first of these is a specialized text dealing with the models of point defects in various semiconductor types. The initial treatment deals with the effective mass theory of the classic shallow impurities in the elemental semiconductors including pairing effects and reviews some
Recent Higher Degrees

Specific Heat Studies of Magnetic Transitions in Rare-Earth Metals

Kasthuri Achchi Kankanamalage Don Dharmawansa Dayaratuna Jayasuriya, Department of Solid State Physics, Research School of Physical Sciences, Australian National University, Canberra.

Ph.D Degree conferred September 1984.

The ferromagnetic and anti-ferromagnetic transitions which take place in gadolinium, terbium, dysprosium and holmium have been examined by specific heat measurements. The measurements were carried out on single crystals over the temperature range 77-400 K using samples of state-of-the-art high purity. A main aim was to delineate the nature (continuous or discontinuous) of these transitions and to determine the exponents $\alpha$ which describe the critical behaviour of the continuous transitions. In its simplest form the specific heat near a critical temperature $T_c$ can be represented by

$$C_p \sim \left( \frac{T}{T_c} \right)^{-\alpha}$$

there remains great interest to both theoreticians and experimentalists in determining the exponents which describe the singularities in various thermodynamic quantities near critical points.

Conclusive evidence for the discontinuous nature of the ferromagnetic to helical antiferromagnetic transitions in terbium and dysprosium at their Curie temperatures has been obtained for the first time from these measurements. The nature of these transitions had previously been undecided with conflicting reports in the literature. The values of the latent heats and the temperature hysteresis in the first order ferromagnetic transitions of terbium and dysprosium were obtained.

The specific heat data around the helical antiferromagnetic to paramagnetic transitions at the Neel temperatures of terbium, dysprosium and holmium and the data around the ferromagnetic to paramagnetic transition at the Curie temperature of gadolinium have been analysed using a power law function which includes confluent singular terms.

The values of the specific heat critical exponents $\alpha$ obtained for terbium, dysprosium, holmium and gadolinium are $0.21 \pm 0.03, 0.24 \pm 0.02, 0.27 \pm 0.02$ and $0.32 \pm 0.02$ respectively. These values are not close to the predictions of renormalisation group theory for magnetic systems with short range interactions. These non-classical values of the critical indices could be associated with the long-range nature of the indirect exchange interaction in the rare-earth metals or with the incommensurate nature of the ordered phase. Furthermore, the results of this study suggest that the critical exponents for incommensurate systems, such as for the rare-earths, are not universal.

Supervisors: Dr A.M. Stewart and Dr S.J. Campbell. Jaya is now working as a lecturer in the Department of Physics of the University of Kelaniya, Sri-Lanka.

Publications

1. "The Specific Heat of GE Varnish (200-400K)"
   K.D. Jayasuriya, A.M. Stewart and S.J. Campbell

2. "Specific Heat Study of the Transition from Ferromagnetism to Antiferromagnetism in Terbium"

3. "The Critical Specific Heat of Terbium"


5. "Magnetic Transitions in Dysprosium: A Specific heat study"

6. "A Specific Heat Study of Natural Haematite Around the Morin Transition and the Effects of Entrapped Water"

7. "The Specific Heat of Samarium Metal (80-400K)"

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Nuclear Magnetic Resonance and Spin Echoes in Metallic Ferromagnets

Robert William Noel Kinnear, Department of Physics, University of New South Wales, Faculty of Military Studies, Dunton.

Ph.D Degree conferred December 1982

In the published accounts of studies of ferromagnetic metals by pulsed nuclear magnetic resonance (NMR), there are many references to the profiles of the spin echoes obtained in the measurements but, until now, a systematic treatment of the echo shapes has been lacking. The work presented in this thesis describes what is, to date, the most extensive experimental and theoretical study of the shape of spin echoes from pulsed NMR of ferromagnetic metals.

The important transition metal ferromagnets iron, cobalt and nickel were investigated using the NMR isotopes $^{57}$Ni and $^{59}$V, with emphasis on Fe$^{57}$V. Features of the echo shapes and line occurrences were characterised by systematic control of the widths and amplitudes of the exciting RF pulses. The main experimental result was the characterisation of the several subsidiary peaks which are often found to accompany the main peak of the spin echo.

A matching theoretical study using the spinor method was carried out; this enabled the motion of the nuclear spins during and between the RF pulses to be followed.

The theoretical calculations were shown to model successfully the experimental echoes, particularly with regard to the structural features and time relationships between the components. From the numerical calculations came the emergence of a previously unknown law of fourth power dependence of the spin echo amplitude on the RF excitation amplitude; this behaviour occurs in the limit of low RF amplitudes.

The theoretical studies were also extended to consider echo formation in the pulsed NMR of oriented, radioactive nuclei. These calculations were designed to match the experimental conditions (in general low temperature $\leq 20$K, high magnetic field $\leq 8$T) of the Dunton nuclear orientation group in order to predict the optimum echoes and thereby derive the maximum benefit from the cryogenic run times.

The main conclusion from this work is that the complex structure in the spin echoes from stable nuclei in ferromagnetic systems is due to the combined effects of inhomogeneous broadening and distributions of the exciting RF field strengths. Also, this work confirms previous indications that the sample state may reduce the often dominant contribution to spin echoes from nuclei in ferromagnetic domain walls.

Supervisors: Prof G.V.H. Wilson and Dr S.J. Campbell.

Bob is continuing in the Physics Department at Dunton and has recently been promoted to Senior Lecturer.

Publications

Structure in Nuclear Spin Echoes from Ferromagnets


Origin of NMR Spin Echoes in Ferromagnetic FeV.


Ectron Pty. Ltd.

N & K Technology Limited, an Australian company, has acquired all the Issued Capital of EAI-Electronic Associates Pty Ltd, and plans to merge it with ECTRON Pty Ltd, a manufacturer of Data Communication Cables and Electronic Speech products. (See Aust. Phys. 22 (2) 67 (1985)).

EAI is the Australian agent for Facit Data Products (a division of L M Ericsson of Sweden), Gould Inc Recording Systems Division and ROLM Mil-Spec Computer Division. In addition, EAI plans to market Ericsson PCs to their customer base in Australia.

EAI has ceased manufacture of the EAI-1000 Analog Hybrid computer in Australia but will continue to represent EAI's (USA based) Simulation computers.
Radio telescope to probe our galaxy

Construction of one of the world's most sensitive and versatile radio telescopes is about to start in NSW, posing a major challenge to Australian engineers and scientists.

It will have instead of the traditional single antenna a combination of 8 antennas spread over hundreds of kilometres.

Known as the Australian Telescope, the $32 million project will have such a high resolution it will be able to pick up detail in space equivalent to reading a telephone directory at a distance of 10km.

This resolution will be achieved by linking antennas at Cungoora, Siding Spring and Parkes to form what is known as a long baseline array simulating a telescope "dish" about 300km in diameter.

Six new 22m-diameter antennas will be erected at Cungoora and one with the same size at Siding Spring, while at Parkes the 24-year-old telescope will be used, giving it a new "lease on life".

The Australia Telescope will be able to receive signals as weak as one picowatt and it will have the capacity of zooming in on particular details in the sky at a ratio of 10,000:1.

It will be used to investigate the centre of our own galaxy, the Magellanic Clouds, interstellar chemistry, black holes and other celestial phenomena.

Being the only one of its kind in the southern hemisphere it will play an important international role in radio astronomy because it will allow astronomers to observe those parts of the sky which cannot be viewed by similar telescopes in the northern hemisphere.

It will also be used — in a way as a byproduct — as a powerful surveying instrument of the Earth's surface.

This application, based on determining a movable telescope's precise position on Earth by using the knowledge of the exact position of certain stars, will allow surveying the entire continent to an accuracy of millimetres.

Such precise measurements will, for example, enable scientists to determine how fast and in what direction the plates of the Earth's crust are moving — a knowledge which should be valuable in predicting not only earthquakes but also the likely location of mineral and petroleum deposits.

Overall responsibility for the telescope construction lies with the CSIRO division of radiophysics in the Sydney suburb of Epping.

The project is planned to have about 80% Australian content. Substantial technology spinoffs in areas such as satellite communications, VLSI technology, cryogenics and computer image processing are expected to flow on into other industries.

Construction is divided into five separate groups: antennas, receivers, signal distribution, correlators and computer processing facilities.

Six antennas at Cungoora will be constructed at the site of the existing radioheliograph which will be dismantled after 15 years of successful operation.

Five antennas will be mounted on a 3km-long railtrack running from east to west. The sixth will be put on a 200km track another 3km to the west.

A series of 37 special foundations will be constructed along the 3km track allowing the five antennas to be positioned in various places at an accuracy of about 1mm. The sixth antenna will be able to assume two different positions.

The antenna at Siding Spring will be mounted in a fixed position.

The six antennas at Cungoora will form what is known as a compact array which, at an operating frequency of 10GHz, will have a resolution of 1 arcsecond.

This resolution is comparable with the best ground-based optical telescopes, said the project director and chairman of the AT advisory committee, Dr Bob Frater.

If the array is linked with Siding Spring and Parkes, the resolution will be about 0.02 arcseconds.

In comparison, other Australian instruments to date have been able to achieve only 20 arcseconds.

Initial operation is planned in a series of frequency bands between 0.3GHz and 50GHz. Later the coverage will be extended to 115GHz which will give the Australia Telescope a total wavelength range from 917mm down to 2.6mm.

The final design which has been developed over a number of years has just been completed.

The antenna structure will be designed to keep the dishes in their paraboloid shape within a tolerance of 0.15mm root-mean-square under a variety of stress conditions, for example dish tipping and extreme wind and sun exposure.

Major experimental work for the dish-panel construction has been carried out by the project's antenna group at the division's workshop in Epping.

As a result the group has come up with a very cost-effective way of producing the panels, said the group's senior mechanical engineer, Barry Parsons.

With relatively inexpensive mechanical equipment the group managed to manufacture several prototype panels with the required accuracy of 0.15mm rms — a feat not previously achieved nor even attempted in Australia, he said.

If this method proves to work satisfactorily on a larger scale, he said, it will save the division thousands of dollars in dish-construction cost.

The signals collected by the dishes will be reflected on to smaller subrefectors, one of which will be centred above each dish. The 2.75m-diameter subrefectors will direct the concentrated signals into feed horns at the reflector focus.

Each antenna will be equipped with four feed horns different in size and shape, as the whole range of frequencies for which the antennas are designed cannot be handled by a single horn.

The two horns for the high frequencies will be conical and the two for the lower frequencies will have a tulip shape.

These tulip-shaped horns, known as compact wideband horns, are capable of handling a wide low-frequency range while being considerably smaller than standard conical horns with an equivalent performance.

The horns used in the Australia Telescope have been developed by the division which has a high international reputation in feed-horn design.

The signals coming through the feed horns will be amplified in receivers cryogenically cooled to — 250°C (20K).

The cryogenic systems, worth $208,000, will be supplied by Cryogenic Technology Inc of the US.

Once the signals are amplified, they will be directed to the control centre, located at Cungoora, where they will be correlated with each other.

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Data from the compact array's six antennas will be transmitted to the digital correlator via optical-fibre cable which will be capable of handling up to 320Mbs for each of the four receiving channels in each antenna. Such a high data rate would be very difficult to achieve with conventional coaxial cable.

The cosmic signal received by the Parkes and Siding Spring antennas will be recorded on high-speed digital tape recorders for later analysis.

So that these signals can be correlated with those from Cugalora they will be time-adjusted with an atomic clock providing an accuracy of 1 picosecond.

Extensive computer facilities will be installed at both Cugalora and Epping, with the bulk of the analysis work being done at Epping. The equipment will be designed to cope with the vast amount of information coming in through the antennas.

From the compact array alone, up to nearly 800Mb of information will be reaching the control centre every second. To be able to correlate signals at that speed, special 5mm VLSI chips, each containing 64 correlators made up from over 30,000 transistors, have been designed at the university.

Altogether 5000 of these chips worth $258,000 will be used in the project. They will be supplied by Adelaide company Austek Microsystems which was established last year.

The whole telescope system, being an Australian Bicentenary project, is planned to be operational by the end of 1988.

Dietrich Georg
Engineers Australia

New silicon technology promises cheaper electricity from sunlight

The first research results in Australia in the field of amorphous semiconductors, have been produced by a University of Sydney team working in collaboration with researchers at the NSF Institute of Technology and the University of New South Wales.

Dr David McKenzie, Senior Lecturer in the Department of Applied Physics, and Mr David Cockayne, the Director of the University's Electron Microscope Unit, are cooperating with Dr Geoff Smith (NSWIT) and Dr Chris Horowitz (UNSW) in an investigation into the atomic structure of amorphous semiconductor materials, which appear 'tangled' when compared with the neat lattice-like structure of crystal-based semiconductors.

Amorphous semiconductor technology offers a much cheaper and simpler method of producing silicon alloys for use in computer chips, electronic circuits, solar cells, light-sensing devices for video cameras and photocopiers, and the many other products of the 'electronic revolution'.

Although their study has only been producing results for two months, the researchers say their work already hints at a way of fine tuning the manufacture of carbon-silicon alloy, which is a component of the cells which produce electricity from sunlight.

Other research projects in Australia on semiconductor technology are at the Telecom Research Laboratories in Melbourne and at the Joint Microelectronics Research Centre at UNSW.

Dr McKenzie says Australia has been slow to embark on research in the field, probably because the Australian electronics industry cannot hope to compete with giant Japanese corporations such as Sanyo and Sharp, which are already marketing calculators, wristwatches and other devices powered by solar panels made from amorphous semiconductors.

'In Japan over the past five years the Government has distributed funds amounting to hundreds of millions of dollars to universities, government institutions and industrial groups for research into amorphous semiconductors, while in the U.S., government support has not been as strong, but is now running at about six million dollars per annum,' he said.

'The great advantage of amorphous semiconductors, which has attracted the Japanese and the Americans, is that the material needed to make them can be manufactured like newspapers coming out of a printing press.

'This compares with the tedious and expensive conventional process of growing silicon crystals, most of which are wasted during cutting to produce "wafers" half a millimetre thick.

'Amorphous semiconductors are often called "thin film semiconductors" because the material can be applied in layers only one-hundredth the thickness of crystal-based semiconductors, using a substrate of flexible plastic film.

'However there is an urgent need for more research into the technology, particularly with regard to its use for conversion of sunlight into electricity (photovoltaic conversion), because amorphous semiconductors are not yet as efficient or as long-lasting as the crystal-based semiconductors.'

Dr McKenzie says the unique combination of expertise and equipment which exists at the University of Sydney was a major reason for prompting a grant of $82,000 from the Australian Research Grants Scheme (ARGS) last year, which enabled work on amorphous semiconductor research to begin.

Original contributor

'Because of our previous work in Applied Physics on selective surfaces for converting sunlight into heat (thermal conversion), and because of the excellent research record of the University's Electron Microscope Unit, we were in a good position to undertake some fundamental research into the atomic structure of specially-prepared amorphous surfaces and make an original contribution to the vigorous research overseas,' he said.

'The grant from the ARGs has allowed the University to add further instrumentation to the transmission electron microscope, which enables us to analyse the atomic structure of amorphous semiconductor materials.

'The techniques we will be using, electron energy loss spectroscopy and electron diffraction, are in fairly routine use in Japan and the U.S., but at the University of Sydney we will have a different emphasis and will be working with different materials.

'We will concentrate on the basic physics, in order to increase our knowledge and understanding of these materials. The Japanese, while not ignoring basic research, have put most of their effort into practical applications.

'The materials we will be using will be produced using the DC magnetron glow discharge decomposition method, which is the same method the Department of Applied Physics has used in producing selective surfaces for conversion of sunlight to heat. This method offers advantages over the conventional 'radio frequency' method of producing amorphous semiconductors with which the Japanese are most familiar.

'In other words, we will specialise in promising areas we know we're good at. It would not be worthwhile to try to beat the Japanese semiconductor industry at its
own game, but we can make a valuable contribution by conducting some fundamental research which could have spin-offs in practical terms.

The group's work will be the measurement of the distance between atoms in amorphous semiconducting alloys. In crystals, atomic structure is a neat 'lattice', and the distances between atoms are uniform throughout. However, amorphous substances appear to consist of 'entanglements' of atoms, a fact which has discouraged most physicists in the past from attempting to analyse their structure.

Although there is an apparent random structure, analysis reveals that amorphous substances, do have a 'short range order', i.e. the close environment of an atom follows a measurable pattern.

The 'short range order' allows systematic analysis and comparison of different amorphous alloys, e.g. silicon/carbon, silicon/germanium, silicon/tin, and of alloys with varying concentrations of the same elements. The concentration of elements in a particular alloy can be established with great accuracy by the new instrumentation on the electron microscope, consisting of a Gatan electron energy loss spectrometer and a Tracer-Northern 5500 data acquisition system.

The EEL spectrometer measures changes in the energy of an electron beam after it has passed through a specimen, which give an accurate picture not only of the kinds of atoms present in the specimen, but also of their bonding with other atoms. The distances between atoms are measured using electron diffraction. Accurate electron diffraction is made possible by filtering out all 'inelastically scattered' electrons and collecting only elastically scattered electrons, using a beam tilting device built in the Electron Microscope Unit. An honours student in Physics, Mr Alistair Sprout, has developed computer software for processing diffraction patterns into a radial distribution function which characterises the materials' structure. Preliminary results in the investigation of carbon/silicon alloys using the system have shown that the atomic structure varies considerably with the temperature of the substrate. The preparation conditions which lead to carbon being bonded in the silicon network in a tetrahedral manner (as in diamond) have been identified. According to Dr McKenzie, this may eventually enable production of more efficient solar cells.

Future work will study the effect on amorphous structures of exposure to light and atmospheric conditions, which may help to improve the durability of solar cells,' Dr McKenzie said.

Concurrently, hydrogen analysis is being carried out in conjunction with Dr S.H. Sie of the CSIRO Division of Mineral Physics using the Heavy Ion Analytical Facility (HIAF). Hydrogen content is also a very important parameter in determining the performance of amorphous silicon devices.

Dr Cockayne says the addition of the EEL spectrometer and its data acquisition system is an important new adjunct to the electron microscope, which will enable further work on a variety of exciting new research projects in addition to the work on amorphous semiconductors.

One of the most interesting of these will be the analysis of frozen biological specimens,' he said. 'The University of Sydney (largely through the work of Dr Thor Bostrom of the E.M. Unit) is at the forefront of low temperature techniques for studying biological specimens, and the ability to specify the location of elements within tissue, such as the distribution of ions (e.g. sodium/potassium/chloride) in kidney tubules, will allow new developments in the study of cell biology.

A co-recipient of the ARGS grant, with Drs McKenzie and Cockayne is Dr P.S. Turner, of Griffith University in Queensland, who is using the facility for an analysis of the structure of Synroc. By characterising phases found in the micro-structure of Synroc, Dr Turner will provide important new information about the properties of Synroc essential to verify its capacity to act as a storage material for radioactive wastes.

Tom Gosling
University of Sydney News

British Institute of Physics

The Council of the Institute of Physics has given approval to the formation of the History of Physics Group, under the chairmanship of Professor A J Meadows of the University of Leicester. The main aims of the Group are to secure the written, oral and instrumental record of British physics for posterity, and to explore ways in which history can be used more effectively in the understanding, teaching and general communication of physics. Since the history of physics deals with all aspects of the subject, the Group also hopes to provide a forum whereby the different and sometimes fragmented disciplines of physics may interact fruitfully.

Four major areas of interest have been identified: oral history and archives; the history of experimentation and instruments; the history of physics ideas; and the history of the interactions between physics and society. The Group intends to pursue these aspects of the history of physics which especially require the skills of the physicist and which are of particular interest to the practitioner of physics. It is generally felt that 19th and 20th century physics will be of greatest interest to Institute members.

Amongst the activities now being planned are the recording of interviews with distinguished senior physicists, the encouragement of historical projects which will shed light on developments in the history of physics, exhibitions of apparatus and texts, a summer school for learning historical skills, and day meetings. The first such meeting will be held on Wednesday 20 February 1985 at Institute Headquarters, London, and is entitled 'Experimenter and instruments: the interaction between experimental skills and instrumental craftsmanship'.

Also newly instigated is the Physical Acoustics Group, under the chairmanship of Dr D P Almond of the University of Bath. The object of this Group is to provide a forum for physical acoustics which will assist in the development of the subject.

The branches of physics covered by the term 'physical acoustics' are the fundamental aspects of acoustic wave propagation and the interactions of acoustic waves with matter. This includes: ultrasonic wave generation, propagation and attenuation in solids, liquids and gases; ultrasonic wave propagation and scattering in solid structures; mechanical relaxation and internal friction; phonon physics; lattice dynamics and the basic physics of ultrasonic testing and imaging, acoustic emission, photoacoustics, acoustic microscopy, and of devices which employ, generate or detect acoustic waves.

It is hoped that the Group will be able to build on the activities of the members who have, in recent years, regularly supported a series of informal physical acoustics meetings. Initially, the group will hold a similar general meeting each year and a number of other meetings of a more specialised nature.

Institute members may join these new Groups by writing to the Records Manager at 47 Belgrave Square. From 1 January 1985 those who wish to belong to the Groups will be required to pay the $2 Group membership fee (or $1 if it is their second Group).
Telecom installs optical fibre link

Digital Equipment Corporation has linked a number of computers serving its internal management information system, over the first optical-fibre customer network to be installed by Telecom.

The link runs some 800m from Digital’s headquarters in suburban Sydney to its software services division. A total of 7 VAX systems at Digital’s headquarters and 4 in the services division now communicate over a 10Mbit Ethernet local area network.

The fibre optic cable, which is customised for data communications use, was manufactured by Austral Standard Cables.

Two Views on the OECD National Science Policy Review

The draft of a major study of Australia’s national science and technology policies has been received by the Government, the Minister for Science, Mr Barry Jones, announced.

Examiners from the Organisation of Economic Co-operation and Development, based in Paris, visited Australia in 1984, looking at the nature and implications of the country’s science and technology policies. Having now prepared a draft report, the examiners will discuss the findings with Commonwealth Government Ministers and representative groups from academia, unions, business and government in early April.

To summarize, the examiners urge that practical application of technology policy be pursued on a sector by sector basis, in accordance with the diverse nature of Australia’s problems and opportunities. Sectoral reviews and co-operation between all of the interests affected would continue the national consensus approach.

The Report recommends a series of sectoral reviews to cover financial services, medicine, horticulture or tourism in addition to the more traditional areas of mining or manufacturing. It is also important to encourage research and development activities by multinational companies operating in Australia.

The Report addresses the essential role of education and training, the relationships between science, technology and industry and the role of government in the overall system.

Recommendations include increased attention to science and engineering education, expanded technical opportunities for women, increased support for university research and facilities (including basic research under the Australian Research Grants Scheme) and greater use of technical employment forecasts to ensure an adequate pool of technically trained people for future industrial requirements.

Special efforts should be made to encourage technology transfer within the public sector and the government should also explore ways to encourage technical training within private enterprise.

The OECD a strongly ministry of science and technology within the Commonwealth Government to concentrate on policy functions; in-house government departmental research would be located within the ministries appropriate to that research.

The OECD Report recommends that research and development should be supported by tax-based incentives schemes, supplemented by industrial fellowships.

Finally, there is a suggestion by the examiners that groups who stand to benefit from CSIRO research should have an increased role in setting CSIRO research goals and meeting the associated costs.

Mr Jones said that the Report would be significant for many groups, both in government and the private sector. He commented that raising the level of scientific awareness and performance in the community was vital for the development of Australia.

Department of Science and Technology

* * *

The Government should encourage more research and development activities by multinational companies in Australia, a major study of Australia’s national science and technology policies has urged.

It said the Government should sell Australia as a place for research and development product centres.

The survey, by the Organisation for Economic Co-operation and Development (OECD), urged Australia to take advantage of decentralised research and development activities by multinational companies.

It said that such companies might decide to place a research and development centre in a country on the basis of competitiveness, taking into account availability and quality of research institutions, trained engineers and labour, production and shipping costs, political and industrial stability, and availability of suppliers.

"It is our belief that Australia has more to offer in this respect than is commonly believed," the survey stated. "It is a democratic, stable country with universities and research institutions that have shown excellent performance in many areas. It is located far away from Europe and the eastern United States but it is comparatively close to those markets (Asia and the Pacific) which at present are showing the strongest growth.

Examiners from the OECD visited Australia last year to look at the nature and implications of the country’s science and technology policies. Their report will be discussed by the Government and representative groups of academics, unions, business and government.

The examiners said they were impressed by the entrepreneurs working in electronic equipment, computer software, medical equipment, vaccines and others. Not all of them would make it but a few may become real winners even internationally." The examiners also noted that some industries were absent, or almost absent, from Australia although the conditions for them seemed favourable.

"Australia, from where we can understand, has medical research of a high international standard, yet there is only a small pharmaceutical industry," the examiners said. "There is undoubtedly scope for further development of pharmaceuticals, perhaps directed toward the niche of high-quality products for developing countries, or protection against tropical human and animal diseases.

"Agricultural research is very strong, yet herbicides, pesticides, and veterinary medicines are hardly produced in the country."

The report recommended that the Government initiate sector-by-sector reviews aimed at establishing science and technology policies and recommendations for each sector. Such reviews could provide a practical way of integrating educational, social and training objectives into a national technology strategy, it said.

Science and Energy
Optical quality control

Since the time of Galileo, many tasks performed in optical polishing workshops have remained essentially unaltered. Grinding and polishing optical components to their final shape is still a laborious task. So, too, is the business of checking the final results. Optical components may look very diverse, but in reality they are usually based on just a few shapes — spherical, cylindrical or flat. Work is often checked on the basis of a test-piece: for example, a convex lens may be placed into a concave depression in the test-piece and examined for closeness of fit, or one side of a prism may be held against a reference flat and checked for parallelism. Often, a monochromatic light source is used to show any failure of the surface to mate with the reference piece through the resultant production of interference fringes. Whether the test surface is spherical or planar, and whether or not fringes are used, the contact method is cumbersome and inaccurate since the test-pieces have to be made in much the same way as the work to be checked.

So how spherical, cylindrical or flat are the test-pieces themselves? The accuracy of even well-made test-pieces comes under suspicion after they have been used many times. Another consideration is the damage that such testing can do to the work itself. Let us say that a mirror or lens is to be produced and that its flatness or sphericity must be better than V/10. Let us say further that He: Ne laser will be the light source, either for inspecting the work or during actual use of the optical device to be tested.

This means that optical polishing has to achieve a flatness or surface quality accurate to within 64 planes of atoms, or thereabouts. (Obviously this is an approximation and depends on the actual material being polished.) The point is, however, that very small distances determine success or failure. It therefore seems absurd to expect an item under test, or a test-piece, to withstand repeated contact with another surface.

Interferometers have always provided a means, in principle, for dispensing with contacting test-pieces and their associated problems. Until now, however, they have been an expensive laboratory tool — beyond the reach of most optical companies. The physics involved may not be new but two things have happened to make interferometers affordable, even to small optical manufacturers. These are: (i) the use of lasers as cheap, reliable monochromatic light sources; and (ii) the application of electronics to simplify and modify the otherwise complex functions of such an instrument.

An interferometer has now been produced which reflects both of these influences, with the result that the instrument is substantially cheaper than previous generations of such equipment. This should allow smaller optical manufacturers to use it in the routine quality control of their processes. It is basically a Fizeau interferometer up to the transmitting output aperture. A small, low-powered He:Ne laser is the light source, and a closed circuit television camera and video monitor provide the means of viewing the fringes produced.

Several useful configurations are possible. Essentially, they all involve precision plane or spherical optics at the output aperture. A Fabry-Perot type cavity is formed between the interferometer and the piece under test; the latter may function as the reflecting right-hand half of the cavity, as in the figure (a). Alternatively it may go in the middle of the cavity, as in the figure (b), with a second precision optical surface at the right-hand side.

Whether one surface only is tested (figure a) or the whole sample (figure b), the method is essentially a non-contact one: no damage is done to either the sample or the reference optics. Very accurate conclusions can be drawn regarding the sample quality (flatness or sphericity) from the interference fringes produced on the video monitor.

These interferometers are produced by a US manufacturer (Zygo), but further information on them can be obtained from Lambda Photometrics of Harpenden.

Peter Holness

From Physics Bulletin

Waste not, want not

Garbage offers significant potential for economically generating energy, according to an English engineer who recently toured Australia talking to representatives from federal and state governments, industry and local councils.

Charles Wells, assistant county engineer for East Sussex, visited Australia as a guest of the Keep Australia Beautiful Council.

He heads a county group which has developed an economical means of turning garbage into fuel. The system is being used in a plant at the English town of Eastbourne and other councils from both Britain and Europe are adopting or adapting the scheme to their own situation, he said.

The Eastbourne plant, based on the Buhler-Miag process, was commissioned in 1979.

After several improvements it now treats some 20,000 t/a of municipal and suitable trade waste and produces about 6000 t/a of fuel pellets with a calorific value of 17,000 kJ/kg (about two-thirds that of coal). In addition, ferrous metals and fine rejects (a compostable material suitable for use as soil conditioner) can be extracted from the waste, further reducing the residue requiring disposal.

The fuel pellets produced by the process are sold to domestic and industrial users.

A great deal of experience has been gained in the design of boilers with automatic feed and de-ashing equipment suitable for fuel pellets. Two trial installations have been operating successfully through a full heating season, Wells said.

The East Sussex County Council is now setting up a larger generating plant in a joint venture with a private company to turn 100,000 t/a of waste into 30,000 t/a of fuel pellets.
Millimetre and Sub-Millimetre Wave Research in Australia

2nd MSM SYMPOSIUM

(Supported by the Australian Telecommunications and Electronics Research Board, and by the Australian Institute of Physics) will be held from 21-23 August 1985, School of Physics, Sydney University.

All correspondence should be addressed to Dr John Macfarlane, CSIRO Division of Applied Physics, PO Box 218, Lindfield, NSW 2070. Tel. (02) 467 6723.

The organizing committee consists of Dr B.W. James, Univ. of Sydney Dr. J. C. Macfarlane, CSIRO, and the following members: Dr J.W. Archer, CSIRO; Dr J.A. How, ANU; Dr I.S. Falconer, Univ. of Sydney; Dr N.R. Heckenberg, Univ. of Qld; Prof. S.M. Hamberger, ANU; Dr L.C. Robinson, Univ. of Sydney; Dr J. Storey, Univ. of NSW; Dr L.B. Whitbourne, CSIRO.

AIMS

The 1985 Symposium aims to provide a forum for scientists and engineers from a variety of research groups in Australia and overseas who have interests and expertise in the millimetre/submillimetre region of the electromagnetic spectrum (approx. 100 - 10 000 GHz). It follows the pattern of the previous Symposium on the same topic (Sept. 1983 in Canberra) which was supported by the Radio Research Board.

The Symposium will take place immediately before the Fourth Australian Laser Conference and the 3rd Conference of the Australian Optical Society. Lectures and meetings will be held in the School of Physics, University of Sydney.

The deadline for contributed abstracts will be 1 July 1985.

THEMES OF THE SYMPOSIUM

Papers will be accepted in the following (and related) topics: Generation of MSM Waves (lasers, gyrotrons, etc.). Detection of MSM Waves (SIS mixers; bolometers; semiconductors, etc.). Applications of MSM Waves (short-range communications; radar; radio astronomy; spectroscopy; industrial processing; plasma diagnostics; etc.). Propagation of MSM Waves (optical components; beamsplitters; materials; etc.).

Hairpin microbalance

Changes in the resonant frequency of a quartz-filament 'hairpin' from which an object is suspended can be used to measure very small changes in the mass of that object. This is the basis for a robust but very accurate and sensitive microbalance designed at Philips Research Laboratories, Eindhoven, which can detect changes of only 10⁻⁹ g in a 5 mg sample. The balance can thus be used to measure the absorption of water by glass or plastic.

The principle of the device is illustrated in the figure. When the piezoelectric flexure element (1) is driven by an AC voltage, the vibration produced is transmitted to a quartz-glass hairpin (3) which in turn makes a second flexure element (2) vibrate and produce an AC voltage.

The frequency applied to (1) is varied around the resonant frequency of the hairpin, and the voltage produced by (2) is then measured, its response, and hence the voltage produced by (2), is at a maximum at the resonant frequency of the hairpin, which can be determined very accurately from the AC voltage produced by (2), is at a maximum at the resonant frequency of the hairpin, which can be determined very accurately from the AC voltage produced by (2) as a function of the frequency of the AC voltage applied to (1). As this resonant frequency is dependent on the load suspended from the hairpin, a change in mass of the load can be accurately determined.

Linkage of the device to a micro-processor means that the voltage maximum from a number of measured values, and hence the change in mass via a calibration curve, can be rapidly determined. The balance can be used for widely differing gas pressures, types of gas and temperatures, provided that the temperature of the piezoelectric elements is not allowed to exceed the Curie point of the material, which is about 180°C.

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Shaky grounds—or high tide?

Hundreds of years ago, when Galileo rose from his knees after formally recanting the Copernican cosmology, he is reported to have muttered under his breath, 'Nevertheless, it moves.'

Much earlier in history, Pliny the Elder stated in his 'Historia Naturalis' that at Cadiz, near the Temple of Hercules, '... there is a closed source similar to a well, which occasionally rises and falls with the ocean, but at other times does the opposite.'

Although Galileo was referring to the movement of our planet relative to the sun, he did challenge the myth of an unshakeable earth. Today, his Inquisitor would be even more scandalized to learn not only that the earth is a spheroid hurtling through space like a badly moulded plasticine ball, but that the changes Pliney observed long ago were indeed caused by tides in the earth itself.

The earth is elastic, viscous, and plastic, and behaves like anything but an ideal heavenly body. Earth tides are caused by the same gravitational pull, exerted by the moon and sun, that causes seas tides.

However, they are obviously much smaller than oceanic tides (because the earth and its interior are much more rigid than the surface waters).

Tidal deformations cause measurable strain in the earth's crust, slight changes in gravity, and tilting at the surface. Although the deformations extend over large areas, they may amount to strains of only 1 part in 100 million, gravity changes of about 1 part in 1 million, or tilt effects of 10^-7 radians (about 0.000006 of a degree) — magnitudes that invite a 'matchstick to the moon' size comparison.

In a deep vault below the Warragamba Dam, 40 miles south-west of Sydney, Mr Ivan Mummie of the CSIRO Division of Mineral Physics has installed a tiltmeter that measures earth tides. The Metropolitan Water Board has made the site available to Mr Mummie for his systematic observations of earth movements, which began in August 1978.

The tiltmeter can also sense 'anomalous' strains in the earth's crust caused by changes in temperatures, rainfall, wind and atmospheric pressure, and 'cultural' strains caused by such activities as excavation.

The deep, insulated Warragamba Dam vault acts as a relatively stable environment in which such extraneous seismic noise is minimized.

Two earth scientists, Dr Jack Rynn and Professor Frank Stacey, both from the University of Queensland in Brisbane, first designed, constructed, and tested the tiltmeter being used at Warragamba Dam.

Obviously, because earth tides and long-term tilts are so small, measuring instruments need to be highly sensitive, and this was one of the first sufficiently sensitive short-baseline devices. It has the advantages of being portable (some earlier models had a base-line of 50 metres compared with the 1-metre base of the Warragamba Dam instrument), easy to install and calibrate, and able to generate continuous records via a chart recorder.

The instrument itself consists of two pools of mercury separated by a narrow connecting tube. The surface of each mercury pool acts as one plate of a capacitor, the other plate in each case being a fixed electrode.

If the surface on which the tiltmeter rests tilts slightly, then at one end of the instrument the plates of the capacitor move closer together while those at the other end move further apart. This causes an imbalance in an electrical circuit, producing an output voltage proportional to the tilt angle.

Apart from the 12-hourly earth tides, the tiltmeter can measure seismotectonic (yes, the same sense as 'teleseismic') tiltting caused by distant earthquakes. During 1979, for example, in the April — December period the tiltmeter recorded more than 160 distant earthquakes, including the tremor that substantially damaged the Western Australian town of Cadoux on the evening of June 2, 1979.

More recently, Mr Mummie has recorded earthquake activity in New Zealand, the Philippines, and Mexico, and in Papua-New Guinea, where tremors have been caused by a volcano next to the Rabaul harbour entrance.

The instrument's most important current application is in testing the possibility that earthquakes in the Sydney region can be predicted by identifying any unusual tilts in the ground.

Mary Lou Considine

A New Kind of Natural Radioactivity

This article is a sampler of the American Institute of Physics Report, Physics News in 1984, which forms a 58-page supplement in the January issue of 'Physics Today'. Reprints are available from the American IP at a reasonable charge.

Natural radioactivity arises from an imbalance in the forces present within the atomic nucleus. Basically, nuclei are held together by the attractive strong forces among the protons and neutrons composing the nucleus. However, there is a repulsive electrostatic force between the protons which ultimately limits how large the nucleus can be. Sufficiently heavy nuclei, such as ones with a large number of protons, decay by ejecting charged particles. This phenomenon was discovered nearly a century ago by Henri Becquerel; the ejected particles, known as alpha particles, were later found to be clusters of two protons and two neutrons, that is, identical to the nucleus of a helium-4 atom. The protons must be ejected in this way, in a cluster, because there is not enough energy to tear a proton away from its closest neighbors. In another kind of decay, nuclear fission, a heavy nucleus can occasionally break up into two nearly equal large blocks. Fission takes place in natural radioactivity, but extremely rarely.

We set out to search for decays involving clusters of a size intermediate between alpha particles and fission fragments. In natural radioactivity, alpha particles are emitted by successive nuclei along a chain of decays. We thought that some of the alpha particles might come out in groups of two or three, in which case the decay products would be, respectively, a beryllium-8 or a carbon-12 nucleus. This decay mode had never before been observed.

Two factors determine the probability of particle decay: the probability that the particle exists somewhere in the nuclear surface and the probability that the performed particle can tunnel through the energetically forbidden region to emerge as a decay particle. The latter factor, the escape probability, was calculated many years ago for alpha particles by George Gamow. We evaluated the escape probabilities for heavy-particle emission to find the most likely cases. Surprisingly the tunneling of C particles was much more probable than C.

Since the other factor in the decay, the preformation probability, could not be calculated, we assumed it to be a factor of a million or so times smaller than the alpha-particle performance factor, and concluded that we might hope to see about one carbon decay for every
few thousand million alpha decays.

As our candidate heavy-particle emitter we chose the nucleus $^{222}\text{Ra}$, which has a favorable escape probability for emitting $^{4}\text{C}$ nuclei. The decay was observed with a standard silicon telescope detector, providing the total energy of the ejected particle and the energy loss rate.

With a total observation time of about 60 days we observed 19 events. The branching ratio for emission of $^{4}\text{C}$ nuclei relative to alpha-particle emission was $8.5 \pm 2.5 \times 10^{-8}$. In terms of the preformation probabilities, it was determined that there is a chance of one in a hundred or so of there being an alpha particle in the nuclear surface, but only one chance in a few hundred million of finding a carbon cluster there.

Recently our work was followed up by an experiment at Orsay, France using a spectrometer, which confirmed radioactivity and showed that the carbon isotope emitted was $^{4}\text{C}$ rather than the more common $^{12}\text{C}$. 

H.J. Rose and G.A. Jones, Oxford University, Oxford, England

Australian Atomic Energy Commission — Reactor Safety Standards Maintained

The AAECC Annual Report for 1983-84 draws attention to the Commission's concern that for several years the level of capital funding available to the AAECC has not been sufficient to sustain Lucas Heights as a first class nuclear research establishment.

Lack of capital funding is a trend which was established under the Government, and can be seen as a reflection of the competition amongst all areas of science for the limited funds available.

Some recent press reports have interpreted this situation as implying that relevant safety standards are not being met in the operation of the AAECC's HIFAR reactor. In fact this is not the case — a program of refurbishment and upgrading of HIFAR has been under way for some time, and necessary funds are being made available for that purpose.

The Report notes that modifications completed in 1983 have brought HIFAR into line with modern plant design philosophy. As a responsible nuclear operator the AAECC is continually reviewing its safety standards — this does not imply that current standards are deficient, and there are no grounds for suggesting that HIFAR is in any way unsafe.

The Commission's Report also draws attention to some concerns with ancillary site facilities, particularly the fire protection of buildings.

New Antarctic Research Instruments Constructed

Australia's developing expertise in polar technology is illustrated by the expanding work of the Antarctic Division's instrument workshop, which has recently completed construction of three new inventions.

Headed by Mr Andrew Fleming, the instrument workshop designs and builds research tools suited to Antarctic conditions.

According to Mr Fleming, they have to be specially built as they are unavailable elsewhere.

Mr Fleming is assisted by three technicians: Brett Gogoll, Shane Nichols and Eric King.

The three new inventions are an under-ice collapsible plankton net, a mud-core splitter and a redesigned ice shear measure.

The under-ice net is used by biologists studying life below sea-ice and beneath the ice cover of lakes in the Vestfold Hills. An 11 cm hole is drilled through ice up to two metres thick, and the net lowered to the required position.

A twist lock similar to a camera lens mount allows the net to collapse so that it can be lowered and raised through the ice hole.

Seven under-ice nets have been built, one of which is being sent to the Indian Oceanographic Institute, which will use it in Indian Antarctic expeditions.

The mud-core splitter will be used to open up plastic core tubes which contain samples of sediment which have been collected from the bottom of Antarctic lakes.

The sediment layers revealed in the mud samples are used to determine the history of the lake environment. Extruding the mud from the tube disturbs these layers and confuses interpretation.

The mud core splitter allows scientists to open the plastic tube without disturbing sediment layers. Two electric motors drive specially constructed adjustable milling heads which cut the tube away from the mud sample.

The ice shear measure is used to determine the movement of ice when it is placed under load.

A section of a core of ice is sandwiched between two plates and a shearing force applied. The ice is bonded to the plates by melting and refreezing. A dial indicator measures the resulting ice movement.

Other projects underway in the workshop highlight the wide variety of specially constructed instruments and tools that are required for Antarctic research.

At various stages of construction are masts for remote weather stations, water samplers, under-ice mud samplers, a bird vomit catcher, a steam operated ice hole cutter, a diver operated push net and equipment for the Division's live krill laboratory.

The workshop also maintains a variety of instruments which are prone to deterioration in Antarctic conditions. At the moment the technicians are repairing an all-sky camera, which photographs auroral activity. A dome shaped glass cover protects a series of mirrors which enable a single photograph to capture the entire night sky.

Solar unit planned for industrial use

A solar-energy collector designed in Western Australia and a power generator developed in Israel seem to match well and suggest good potential in some industrial applications, according to their developers.

Nova Sun Energy Ltd of Perth and Ben Gurion University in Israel have been conducting negotiations for joint development and marketing of a solar power unit.

Nova Sun began detailed technical and economic research on a "centrally focusing hemispherical solar energy concentrator" (CFHC) in 1981.

The CFHC is a large modular solar-energy collector designed to produce heat for heavy-duty industrial applications such as steam-enhanced oil recovery and alumina refining.

It has also been designed to generate electricity in conjunction with energy conversion devices.

It is based on existing spherical bowl technology but incorporates an innovative feature, the caustic correction cone, giving it the performance characteristics
Speech Research Project Brings New Hope

Speech handicapped children, accident and stroke victims, have been given hope of overcoming their problems as a result of new research.

Scientists at the Medical Physics Group of the Physics Department at Exeter University in south-west England, have teamed up with local dentists, doctors and speech therapists to develop a range of equipment to help children overcome dysarthria — abnormal behaviour of the muscles controlling speech and swallowing, causing drooling and hypernasal speech.

The equipment has also found another role, helping older people whose speech and swallowing have been impaired after a stroke, or through accident injuries.

Dr Frederick Flack and Mr Dick Ellis, the two scientists who first started the project, have developed aids which are now in use in several countries, including Australia, Hong Kong, Argentina, South Africa, Denmark and New Zealand.

One successful piece of equipment is the Exeter lip sensor unit, which looks like a small transistor radio.

"This was designed to help children with only limited lip control, who cannot tell whether their lips are open or closed. A clip placed on the lower lip is wired to the sensor, which emits a beep until the lips are closed," says Mr Ellis.

A more advanced version rewards the youngsters by playing music when they bring their lips together, helping them regain control of the lip and thus improve the quality of their speech. Production models of this version are now in use worldwide.

Another aid for speech-handicapped children is a nasal anemometry system, which enables speech therapists to monitor airflow through the nose during speech. A small plastic mask placed over the face is linked to a stereo cassette machine which records speech and airflow on separate tracks. The recordings can then be analysed and converted to chart form for the therapist, providing a detailed picture of how and where air is escaping.

An aid originally developed to improve the clarity of children's speech has also proved a great help to stroke and accident victims by stimulating their swallowing reflexes. A palatal training device, rather like an upper denture, has a metallic loop which is in contact with the soft palate at the back of the roof of the mouth. This is linked to a light which comes on when the soft palate is at rest, and goes out when the palate is lifted, teaching patients how to control movement of the palate, and swallow normally.

Another research project at Exeter is aimed at identifying children with swallowing problems early on in childhood. At a special baby care unit, mothers are feeding their babies with bottles electronically linked to monitoring equipment which records the basic feeding pattern of suck, swallow and breathe.

"By establishing the co-ordination pattern of these events for a normal baby, we hope to be able to spot those babies with any abnormalities and ensure that special attention is given, so that any difficulties can be overcome early in childhood," explains Dr Flack. Several babies have already been successfully treated, ensuring that they have the best possible speaking abilities before starting school.

Disagreement on leg veins

The way blood flows in our leg veins is currently the cause of considerable disagreement among vascular surgeons. Although the problems of varicose veins and leg ulcers are well known, their exact cause is still being discussed.

Blood return in a healthy leg relies on two systems. There is a "slow return" system through the large surface or saphenous veins that are connected through the so-called perforator veins to the deep vein system running up the inside of the leg. This second set of vessels allow blood to be pumped back to the heart by the movement of muscles and valves.

However, when a patient suffers from bad venous drainage, doctors disagree about which set of veins is responsible. David Tibbs of the John Radcliffe Hospital in Oxford, England, believes around half these patients have incompetent surface veins, so that when blood is pumped up the deep vessels much escapes back down the surface system. The cure is removal of the outside veins on the leg.

A quarter of the cases of varicose veins and ulcers are the result of deep vein blockages causing blood to pass out of the connecting veins (perforators) and up the surface veins. In this case, the usual varicose veins surgery does not help. Finally, about a quarter of patients have faulty vessel valves and blockages in the iliac vein, which takes the blood from the leg to the heart.

Mr Tibbs bases his thinking on the results of the work he has done with a Doppler based image intensifier. He has been able to monitor the blood flow in the perforator veins using surface probes and how he believes that, with these techniques, doctors should be able to spot causes of venous insufficiency that are curable by surgery.

A British company, Andrew Stephens, has just marketed a new range of hand-held Doppler probes. The 5 and 8.2 MHz models are especially designed to help surgeons identify which way the blood flows in the deep leg veins of patients. Signals from the probes are magnified by an amplifier unit that can be connected to headphones or recorder.
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