the
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physicist

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THE CALENDAR

August, 1972
8 Space Physics, Sydney Uni. (NSW-AIP); A. G. Klein, Dept of Physics, Melbourne Uni.
14-18 American Scientific Exhibition, US Trade Centre, Sydney (Tickets from The Director).
21- Radioisotope Course for Non-Graduates, Lucas Heights, NSW (ASNT; see AP May 1972).

October
16-17 Second AINSE Neutron Diffraction Conference, Lucas Heights, NSW.

November
13- Radiosotope Course for Graduates, Lucas Heights, NSW (ASNT; see AP June 1972).

January, 1973

February
5-9 Physics of the Upper Atmosphere, Semiconductor Principles and Applications, Environmental Physics, Qld Uni. Summer School (Qld-AIP; see AP May 1972).

AIP Annual General Meeting (during Qld Summer School).
2ND AINSE
NEUTRON DIFFRACTION
CONFERENCE
LUCAS HEIGHTS, NEW SOUTH WALES
16-17TH OCTOBER 1972

An informal conference reporting recent research and technical developments in the field of Neutron Diffraction, will be held in the AINSE theatre at Lucas Heights on Monday 16th and Tuesday 17th October 1972.

Program

It is planned to have review and research papers, presenting work in progress or recently completed on:—

(1) Chemical Crystallography; molecular & biological structures, inorganic chemistry.
(2) Diffraction Physics; extinction, Debye-Waller factors, bonding effects.
(3) Inelastic Scattering; phonons, magnons, molecular dynamics.
(4) Magnetic Structures; polarised neutrons, phase transitions.
(5) New experimental methods and industrial applications of neutron diffraction.
(6) Data Handling; statistics, computation and direct methods.

Nominations and offers of papers, relevant forms, etc., available from the conference secretary.

All persons interested in Neutron Diffraction and wishing to participate may obtain full details of the conference from:—

Mr. D. A. Wheeler
Conference Secretary
A.I.N.S.E.
Private Mail Bag
Sutherland, N.S.W. 2232

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(3) Lecture Courses. From time to time lecture courses will be conducted on various aspects of information and library services.

The first of these will be held at the Coronation Motor Inn, Artarmon, 6-8th September, 1972, entitled “Introduction to Library Automation”.

For further information on any of these services please write to the above address.
CURRENT RESEARCH ON MAGNETIC STORM PHENOMENA IN THE UPPER ATMOSPHERE

K. L. Jones
Physics Department, University of Queensland

One of the earliest observations of the behaviour of ionized constituents in the upper atmosphere was that during some magnetic storms the maximum electron concentration fell by up to an order of magnitude (Hafstad and Tuve 1929). Since then it has been observed that on some occasions it rises by a factor of two or more. Energy from the ‘solar wind’ is stored in the Earth’s magnetosphere which from time to time becomes unstable, resulting in the sudden deposition of energy in the ionosphere (altitude range 100-800 km). The magnetic fields of electric currents associated with this energy release are detected by ground-based magnetometers. Hence the term ‘magnetic storm’ (See figure 1).

The ionosphere is formed from atomic oxygen, but the recombination rate above 200 km is strongly controlled by the concentration of molecular species which decreases rapidly with altitude. The plasma concentration is thus very sensitive to changes in the [O]/[N₂] ratio. For example, if the ionized constituents are maintained 50 km above their ‘normal’ altitude in the daytime, the balance between production and decay of ionization is changed so as approximately to double the maximum plasma concentration.

Three mechanisms have been proposed for effecting such height changes. Firstly, east-west electric fields crossed with the geomagnetic field give the plasma a vertical component of motion [Martyn 1953] (see figure 1). Since the advent of satellite measurements of air densities at ionospheric heights, it has been realized that electrodynamic motions of plasma at mid-latitudes will be heavily damped by the neutral air [Dougherty 1961, Bramley 1969], and it appears that such motions will not produce the large global scale changes often observed [Jones 1971].

Secondly, atmospheric heating at high (auroral) latitudes during magnetic storms may alter the neutral air wind velocities in the upper atmosphere [Cole 1962]. An extra component of velocity toward the equator is produced. In the absence of a magnetic field the horizontal velocity (u) of the neutral air would, by collisions, be imparted to the ions. However the Earth’s magnetic field allows the ions and electrons only the component of u in its own direction. Thus the field acts on the plasma to give it a vertical component of motion (figure 1). This mechanism is a promising one for explaining large daytime increases in plasma concentration [Jones and Rishbeth 1971].

Theories of Plasma Processes

The physical processes causing the order of magnitude changes in ionospheric plasma concentration are not well understood. It has been suggested that storm increases may be due to compression of plasma from the outer magnetosphere down to ionospheric heights [Bauer and Krishnamurthy 1968, Papagiannis et al 1971]. For a number of reasons this writer does not believe such processes to be effective enough to produce the frequently observed increases of 50 per cent. or more.

The origin of large changes in ionospheric plasma concentration is more likely to be due to a modification of the recombination rate of ions and electrons. This loss rate decreases with altitude above 200 km because of the ‘dissociative recombination’ process [Bates and Massey 1947]. Perhaps the most important such reaction is

\[ \text{O}^+ + \text{N}_2 \rightarrow \text{N}_2^+ + \text{O} \]

\[ \text{N}_2^+ + \text{e}^- \rightarrow \text{N} + \text{N} \]
Thirdly, storm generated disturbances may upset the diffusive equilibrium under gravity which exists above 120 km for different neutral constituents [King 1967]. This is a likely mechanism for explaining the occurrence of large decreases in plasma concentration [Chandra and Stubbe 1971].

Experimental Program

At Brisbane we are currently conducting theoretical studies of ionospheric dynamics in conjunction with experimental observations of ionospheric phenomena.

Observations are made by ionosonde (a ground-based radar which yields plasma concentrations up to the height of maximum plasma concentration, but not above) and by measurements of the change of polarization of 137 MHz signals from the geostationary satellite ATS1 (giving an estimate of integrated electron concentration right through the ionosphere and hence some idea of the behaviour of the other 60 per cent. of the plasma not visible to the ionosonde). The 137 MHz polarimeter is shown schematically in figure 2.

The antenna is rotated at 1 Hz thus imposing a 2 Hz amplitude modulation on the signal. The phase of this modulation is compared with the phase of a reference signal derived from the rotation of the antenna.

Figure 2 also illustrates some storm observations at Brisbane. We are currently extending our program of observation to include that of polarization and phase changes of 150 and 400 MHz signals from a set of satellites in 1000 km orbits. Thus we shall obtain information on the spatial variation of ionospheric parameters to complement the temporal variations obtained from the geostationary satellite observations.

Similar observations are being made at other Australian observatories and in many other parts of the world. The global character of the phenomena makes cooperation on an international scale essential.

References


New Fellows of Australian Academy of Science

Dr. A. C. Hurley, Chief Research Scientist, Division of Chemical Physics, CSIRO. Dr Hurley is best known for his contributions to the electronic theory of small molecules. He has extended the molecular orbital theory of chemical valency, and developed new methods for the electrostatic calculation of molecular energies. Dr Hurley's detailed investigations of the method of atoms in molecules have resulted in new techniques for calculating the binding energies of molecules.

Professor G. M. Kelly, Professor of Pure Mathematics, University of New South Wales. Professor Kelly had played a leading role in the development over the past decade of category theory. In that time the theory has developed into an all-embracing mathematical discipline which today pervades almost all fundamental structures of mathematics.
THE REGISTER

CHANGES IN MEMBERSHIP FROM 18 APRIL TO 7 JUNE 1972

Fellowship

(a) New Elections
Allen, B. J. Australian Atomic Energy Research Establishment, NSW
Whineray, S. Australian National University, ACT

(b) Transfers
Crisp, R. S. University of Western Australia

Associateship

(a) New Election
Fisher, G. CSIRO Division of Food Research, NSW
Kent, R. D. Royal Melbourne Institute of Technology, Vic.
Quilty, J. H. Bureau of Mineral Resources, ACT
Van Megen, W. J. Royal Melbourne Institute of Technology, Vic.
Young, A. D. Royal Melbourne Institute of Technology, Vic.

(b) Transfers
Blackburn, P. B. Bureau of Meteorology, Vic.
Higinbotham, J. University of New South Wales Bureau of Meteorology, Vic.
Jasper, J. D. CSIRO Division of Building Research, Vic.
Keating, W. G. Fremantle Technical College, WA
Lullfitz, R. C. Defence Standards Laboratories, Vic.

(c) Resignations
Enval, B. (Vic) Richardson, L. A. (NSW)

(d) Removals
i) Under Clause 13 of Articles of Association:
Bala Subramaniam, E. (Qld) Lokan, K. H. (Qld)
ii) Address Unknown:
Taylor, K. J.

Graduateship

(a) New Elections
Boardman, W. J. University of Western Australia
Cain, G. J. Monash University, Vic.
Joyce, A. P. Education Department of Western Australia
McCulloch, M. T. Western Australian Institute of Technology
Nielsen, P. J. University of Papua-New Guinea
Sontor, M. J. Macquarie University, NSW
Ward, A. R. Monash University, Vic.

(b) Transfer
Currie, P. D.

(c) Resignations
Brown, R. J. (Vic)

(d) Removals
i) Under Clause 13 of Articles of Association:
Acher, R. S. (Vic)
Barry, A. B. (ACT)
Dimond, R. K. (Qld)
Lund, T. (Vic)
Treycey, B. J. (NSW)

ii) Address Unknown:
Denham, R. A.

Students

(a) New Elections
Adams, G. E. (Qld) Barryk, J. E. (Qld)
Clynes, E. (NSW) Collocott, S. J. (NSW)
Corben, B. F. (Vic) Coates, H. L. (Vic)
French, D. W. (Vic) Heurigian, C. (Vic)
Joyce, A. R. (ACT) Kennedy, G. D. M. (NSW)
Layne, M. (Vic) McMurrin, R. L. (ACT)
Marshman, L. W. (Vic) Naylor, R. G. (Vic)
Nicholson, R. G. (NSW) Potts, R. J. (WA)
Purton, P. J. (WA) Reid, J. D. (ACT)
Swiney, P. G. (NSW) van Riesen, A. (WA)
White, G. L. (NSW)

(b) Removals
i) Under Clause 13 of Articles of Association:
Cameron, M. J. (NSW) Fitch, P. S. (SA)
Holland, G. J. (NSW) Logounov, G. (NSW)
Mann, J. P. (WA) Petersen, M. G. (NSW)

ii) Address Unknown:
Goodwin, G. C.
Young, R. W.

Subscribers

(a) Resignations
Bel, J. G. (NSW) Cairns, R. M. (WA)
Carey, S. W. (Tas) Spiegg, R. G. (SA)

(b) Removals
i) Under Clause 13 of Articles of Association:
Atkinson, D. A. (SA) Heybroek, B. (NSW)
Howe, B. A. (NSW) Whiteley, R. J. (NSW)

ii) Address Unknown:
Rae, L. A.
Equipment to date ceramic objects using the phenomenon of thermoluminescence (hereafter referred to as TL) is being set up in the Physics Department at the Australian National University. This equipment will be used in co-operation with the two Departments of Prehistory at the University to supplement other methods of dating such as the well-known radiocarbon technique which cannot be used in such cases. It appears that, in the Pacific region, objects which have not participated in the carbon cycle are found more commonly than those which have. Even in Australia, where pottery is absent, samples of baked earth adjacent to aboriginal fires are susceptible to dating by TL. In the Riverina area such deposits are found which extend back 30,000 years. The technique also has advantage over magnetic dating as the samples need not be found in their original positions.

A simple description of the technique is worthwhile because it represents a good example of the application of physics to the solution of a technological problem.

All pottery and ceramics contain trace amounts of long-lived radioactive isotopes of uranium, thorium and potassium which emit radiations which in turn produce ionization of the constituent mineral atoms. Progressive energy storage takes place in the matrix of the object due to trapping of the wandering electrons at defect sites—this energy may be released by a controlled heating of (a sample of) the object. During this heating the electrons de-excite by recombination with their parent or similar atoms. This recombination is accompanied by the emission of light which is termed TL. An experimental arrangement for measuring this TL is shown in the figure 1.

As the pot was fired during its manufacture—effectively emptying all traps—measurement of the amount of TL radiation given off during the second (laboratory) heating gives a measure of the time during which energy storage has taken place: this may be used to date the pot. One can think of the measured TL as representing a record of the total radiation dose received by the material of the pot over the period between its first and second heating. Thus the age is given by:

$$\text{Age (years)} = \frac{\text{Total radiation dosage}}{\text{Annual dose rate}}$$

The relation between the total radiation dosage received and the measured TL is established by subjecting the specimen to a known dose of radiation from a laboratory radionuclide source and then measuring the artificial TL so induced. The annual dose rate is determined by assaying the sample for radioactive content as well as estimating the external dosage component. In an average case the internal dose rate can amount to 0.4 rads/year while that due to external sources (gamma radiation from the soil in which the object was buried and cosmic rays) amounts to 0.08 rads/year. A dating accuracy of approximately ± 10 per cent. is generally possible using this technique although this may be increased in good cases to ± 3 per cent.

The technique may be used for authenticity testing of ceramics, in which case a much lower accuracy of age determination may be tolerated. Thus a genuine piece of Chinese T'ang ware may be about 1000 years old whereas a modern reproduction could have been made only 60 years ago during the initial period of popularity of such material in western art markets.

For those who wish to read further into the subject reference can be made to a recent review by Aitken [1970].

Reference
THE PAWSEY MEMORIAL LECTURE 1972

PHOTONS AND STARS

R. Hanbury Brown
School of Physics, University of Sydney

I am glad to give the Pawsey Memorial Lecture because I knew Joe Pawsey for many years. I first worked with him on aerials for aircraft radar in 1939 and it was in 1960, when he was staying with us in Alderley Edge near Manchester, that we discussed a proposal that the Stellar Intensity Interferometer should come to Australia. It was on Joe Pawsey's advice that I accepted the offer by the School of Physics of the University of Sydney to share the costs and to install the interferometer in New South Wales. I hope to persuade you that his advice was good.

The problem which we sought to answer is how large are the pinpoints of light we see in the night sky and call stars? This is an old problem and many people have tried to answer it. Among them is Galileo. He was concerned to answer an objection to the Copernican idea that the earth goes round the sun. This objection was founded on the observation that the stars do not appear to move in the sky during the year as one would expect if the earth really did go round the sun. If one supposes that the stars are so far away that this motion is too small to be observed, then there is a serious difficulty. The accepted value of the angular diameter of a bright star was about 2 minutes of arc and this was supported by the authority of people like Tycho Brahe and Clavius. If, now, we put the stars far enough away to reduce their apparent motion, their actual size would be much larger than the sun, in fact as large as the orbit of the earth. This conclusion was regarded as absurd. Galileo, characteristically, checked this figure of 2 minutes of arc by experiment. He hung a fine cord vertically and then measured the distance at which he had to stand so that the cord just occluded the bright star Vega. He was a most careful experimenter and he allowed for the convergence of the light in his eye by an experiment with strips of black and white paper which is all recorded in his book, "Dialogue concerning the two chief world Systems". Galileo measured Vega as 5 seconds of arc. It would be quite interesting to repeat this experiment; perhaps it could be substituted in First Year Practical Physics at Sydney University for the experiment in which the students measure the height of that monstrously ugly piece of old iron which I believe is an example of modern art outside the Fisher Library. Anyway, I believe you would find it hard to do better than Galileo. The value he got, 5 seconds of arc, has nothing to do with diffraction but is presumably just a measure of the local atmospheric 'seeing'. We now know it is 1500 times too large.

The first successful attempt to measure a star was made by the American physicist Michelson in 1920. Together with Pease, he measured 6 stars with angular diameters in the range 47-20 \times 10^{-3} seconds of arc. He did this with the well-known Michelson interferometer, 20 feet (8m) across. This interferometer brings together two beams of light received by two small separated mirrors and interference fringes are formed. If we measure the mirror separation at which these fringes disappear, we can find the angular size of the star. Michelson's interferometer is limited by two particular things. Firstly, it must be made and guided at the star with very high precision. Any path difference between the two sides must be, roughly speaking, no greater than a wavelength of light. This is very hard to achieve in a big structure. Secondly, it is vulnerable to atmospheric scintillation which moves and distorts the fringe pattern rapidly. Attempts were made by Pease to increase the size of the instrument from 20 feet to 50 feet (8m to 17m), but they failed and the work was discontinued in about 1937.

The next successful measurements were made with an intensity interferometer and it is about them that I am going to talk this evening. An intensity interferometer consists essentially of two spaced photoelectric detectors. Light from the star falls on these detectors and gives rise to a pulse of current for each incident photon. We now measure the coincidence in time between these pulses. Mathematically, we can analyse the operation of this instrument by representing the light as a classical electromagnetic wave which falls on a quantized detector. That is to say, there are certain discrete energy levels in the detector corresponding to the release of an electron. It can be shown, using this model, that the probability of emission of a photoelectron is proportional to the square of the electric vector of our incident wave. If the electric vectors are correlated at the two spaced points, as they are for coherent illumination, then the probabilities of ejection of photoelectrons are also correlated in the two detectors and so the coincidence rate is increased. It can be shown that this coincidence rate is proportional to the square of the visibility of the fringes in Michelson's interferometer, and so we can observe the coincidence rate, or correlation, as a function of the detector spacing and find the angular size of a star. The only thing we lose is the phase of the visibility of the fringes. This means that an intensity interferometer cannot give you a unique picture of an asymmetrical object. For example, when viewing a double star with components of different brightness, it can't tell which way round the components are in the sky.

However, an intensity interferometer has two great advantages. The pulse of current, corresponding to a photon, is about 10^{-6} s in duration for a typical photo-multiplier. If now we delay one pulse by a small
fraction of this time, say $10^{-9}$ s, then the coincidence rate is not going to be affected much. In practical terms this means that the whole construction of our interferometer can be relatively crude and we can make it very large indeed; furthermore, and this is most important, the atmosphere cannot introduce relative delays into two light paths of much more than $10^{-11}$ or $10^{-12}$ s at the most, and so it cannot upset the function of the instrument. We have thus solved the two main difficulties of increasing the size of Michelson's interferometer. We have paid for this gain in having to build very large reflectors to collect the light. Unfortunately, when you square the electric vector at the photocathode, you also square the signal-to-noise ratio and an intensity interferometer is very insensitive.

All this discussion is fine when you are talking to radio-engineers. They don't worry about photons, to them a wave is a wave. But physicists do worry and when we started this work we had some serious opposition. Some people didn't like the idea of being correlated in time because, in a thermal emitter, they start at random. Some people thought that the sacred books of quantum mechanics prohibited the whole thing. For example, in a beam of $n$ quanta, forming a wave of phase $\phi$, it can be shown that the uncertainties, $\Delta n$, $\Delta \phi$ are non-commuting and $\Delta n \Delta \phi \approx 1$ and so one cannot measure the phase and the total energy in the two beams with indefinite accuracy as we proposed. Another more recondite objection is that our semi-classical picture of the photoelectric effect gave apparently the wrong answer for the fluctuations of energy in a grey body in an isothermal enclosure.

We managed to dispose of one trouble by pointing out that there are two beams of light with phases $\phi_1$, $\phi_2$ and $n_1$, $n_2$ photons. We were proposing to measure only the relative phase of these beams ($\phi_1 - \phi_2$) and the total energy ($n_1 + n_2$) and these do commute so that,

$$\delta (\phi_1 - \phi_2) \delta (n_1 + n_2) = 0$$

and there is no theoretical objection to the intensity interferometer on these grounds. The troubles about the grey body were harder to resolve and it took us quite a time to see what was wrong. Quite simply the thermodynamic argument, on which the classical formula is based, treats the streams of radiation emitted by the body and falling on the body as independent. In fact, they interact and when this is taken into account, the answer given by our analysis was found to be correct. But the more general problem is that people try to use a particular mental picture of light to answer an inappropriate question. When the problem is about waves, then one must picture light as a wave. When the problem is a particle problem, involving a single particle, then one must think of the photon as a particle. But beware. When there is more than one photon, then the photons lose their identity and the picture of photons is likely to give the wrong answer. There is nothing new about this type of problem. Look back a few centuries at the theologians, the theoretical physicists of their day, grappling with a working model of the Trinity. The Athanasian Creed struggles with a problem like wave–particle duality, except that it deals with three incomprehensibles. Listen to this, "As also there are not three incomprehensibles, nor three uncreated, but one uncreated and one incomprehensible". Again, consider the question of associating wave-like properties with a particle, "the Holy Ghost is of the Father and of the Son, neither made, nor created, nor begotten, but proceeding". We live by working approximations and mental pictures of what we call reality and people have always done so. Finally, let me remind you that the Creed ends with the sentence, "He therefore that will be saved, must thus think of the Trinity". Our present position is simply, "he therefore that will get the right answers, must thus think of Light".

In retrospect I find it ironic that we should have had all these battles about photons when, in fact, one does not need to worry about photons at all. Radio engineers don't question our radio intensity interferometer and I don't see that physicists should worry about our optical interferometer. In almost all textbooks it tells you that the photon was needed to explain the photoelectric effect. This is not so; you do need it to deal with the Compton effect and some other things, but not the photoelectric effect. One can get all the photoelectric equations in terms of the semi-classical model using waves.

In the end we won all our battles of principle and we built an optical interferometer and brought it to Australia in 1961. With this instrument we measured the angular diameters of 32 stars in the temperature range 50 000 to 7000 kelvins. These are the first and only measurements of the main sequence stars. Michelson's six stars were all cool, nearby, giants or supergiants, by no means representative of the commonality of stars. But it is not about single stars that I want to talk. I want to tell you about another experiment on a double star, Spica or α Virginis, which consists of two stars which revolve around each other in 4 days. We watched this star with the interferometer for a month on two occasions a few years apart. In effect we measured the angle subtended by the two stars as a function of time. We then made a model of a double star, a mathematical model in a computer, and we put all the observations into this computer and let it match the model to our observations. There are 12 parameters of a double star plus the unknown sense of rotation. We took some of these parameters from the optical data about the star, which is a double-lined spectroscopic binary, and let the computer find the unknowns. Among other things the computer found the inclination of the orbit, which you can't find from spectroscopy, and the angle subtended by the orbit at the earth. If you combine these data with the spectroscopic data you can find out almost everything about the stars. The astonishing thing is that you can get its distance from the physical size of the orbit and the angular size of the orbit, and this came out to be 274 ± 12 light years ($84 ± 4$ parsec). I would remind you that this is a geometrical measurement, independent of interstellar extinction, and that the limit of the classical
method of parallax is about 30 light years (9 parsec) for comparable accuracy. This experiment points to what could be done with a larger instrument with which more binary stars could be measured.

This brings me to my final remarks. We propose to shut down the Stellar Interferometer this year. It has done its job and we want to build a larger one. In the figure is a sketch of what we want to build. This is another intensity interferometer but of different design. The railway track is straight and not circular so that it can be extended, the paraboloidal reflectors are stationary and do not move as at Narrabri. The starlight is reflected into the stationary paraboloids by moving flats, called coolstats. These flats move on the railway line so that they give the desired baseline and also equalize the times at which the light reaches the two sets of paraboloids. There are four paraboloids and four coolstats, all 40 feet (13m) in diameter. The instrument would be 100 times more sensitive than the interferometer at Narrabri and should reach to stars of at least magnitude +7. It would reach at least 3500 stars, 39 binary stars and 9 Cepheid variables. Perhaps I should add that the prospect of measuring the pulsations in radius of a Cepheid variable is something which I regard as so attractive that it, alone, would justify the cost of the instrument. By combining measurements of the apparent change in angular size of a Cepheid with spectroscopic measurements of the radial distance travelled by its atmosphere, one should be able to measure directly the distance of a Cepheid. Such a measurement would be an independent check on the scale of distances in the Galaxy. Finally, I should say that we have not yet received an answer from the Federal Government as to whether they will finance this instrument, but we live in hope.

LIQUID CRYSTAL INSTITUTE AT KENT

Elmar Laisk
School of Physics, Macquarie University

Introduction

The discovery of a liquid crystal phase in a chemical compound of cholesterol by the Austrian botanist H. Reinitzer in 1888, has led now to worldwide research activities notable amongst which are those at the Kent State University in Ohio, USA. The Institute was founded in 1965 and carries out inter-disciplinary research using techniques such as n.m.r., e.s.r., Mössbauer effect, infrared spectroscopy, X-ray diffraction, light scattering, Raman scattering, ultrasonics, chemical calorimetry, diffusion, viscosity and optical studies, and their dependence on temperature and the presence of electric and magnetic fields.

Classification of Liquid Crystals

A large number of organic substances exhibit, when slowly heated, a semi-liquid 'mesomorphic' phase between the crystalline solid and entirely isotropic liquid state. In this mesomorphic phase the substance behaves like a liquid but performs optically like a crystal, exhibiting double-refraction, optical rotation and circular dichroism. Hence the name 'liquid crystal' which was first suggested by O. Lehmann who between 1890 and 1915 wrote four books on anisotropic liquids or 'paracrystals'.

For instance, cholesteryl nonanoate, when slowly heated, turns into a viscous liquid at 78°C but then polarizes light and scatters it selectively, displaying iridescent colours in either reflected or transmitted light. However, at 91°C the substance suddenly turns into a proper isotropic liquid without any optical activity. Hence the mesomorphic or liquid crystal phase for cholesteryl nonanoate exists over 13 degrees. For other liquid crystal substances this range may be only a few degrees.

From Lehmann's few hundred, the number of liquid crystals has increased steadily into thousands today, a good part of them listed by Kast in the Landoldt-Börnstein chemistry data book. The first known liquid crystals were all cholesterol compounds having long flat molecules forming helical structures in the mesophase so that their optical activity and associated colour display depend very sensitively on the temperature.

Such thermotropic behaviour characterizes cholesteric liquid crystals. There are also nematic liquid crystals which, in thin films, produce light scattering in an electric field, and smectic mesophases with somewhat complex physical properties. Some soap–water solutions may also become anisotropic and are termed lyotropic liquid crystals.
The molecules of a liquid crystal form more or less ordered structures in the mesophase, due to the alignment of the strong dipole moment of the elongated molecules, and due to the asymmetry in chemical double-bonds. Thus, the liquid crystal substances are not limited to cholesteryl esters but include also many azo and azoxy compounds and anilis. Most often the basic units in a liquid crystal molecule are aromatic groups bound by some specific linkage groups; or they may be built from cyclic groups, all having characteristic terminal groups attached to carbon atoms at specific sites.

The least ordered of the mesomorphic phases is the nematic one in which the molecules are aligned parallel to their molecular axis. In the cholesteric mesophase the parallel-aligned molecules form helical structures ("twisted nematic"); whereas in the smectic mesophase the axially aligned molecules form distinct molecular planes.

More often than not the liquid crystalline state shows polymorphism by which the transition from the solid crystalline state to the isotropic liquid exhibits several smectic textures followed by a nematic one.

Research at the Liquid Crystal Institute

For some time, only three smectic textures termed A, B and C were known. Currently several others, possibly eight altogether, have been identified at the LCI. Surprisingly, de Vries at LCI has also proposed the existence of three phases in some nematic states. The two new nematic or cybotactic phases are believed to consist of regular clusters of otherwise nematic molecules.

Other work at the Liquid Crystal Institute includes various aspects of liquid crystal theory, investigations into molecular structure and coupling energies and the synthesis of liquid crystals (including multi-component mixtures). Although much basic work remains to be done there is already an acute interest in all kinds of applications of liquid crystals such as for alpha-numerical indicators, optical shutters and filters, large screen displays, image intensifiers, infrared microwave visualization devices and a host of biological and medical applications.

NOTES AND NEWS

Auger Electron Wall Chart

Varian Vacuum Division is now distributing the second edition of a wall chart designed to aid surface science studies. The chart documents the energies of Auger electrons arising from the excitation of different elements by medium energy electrons. It displays a composite of experimentally observed and identified spectra and also theoretically predicted Auger peaks. The chart includes new information from recent work performed with Auger spectrometers. Its main application lies in the identification of peaks in an Auger spectrum when an unknown material is being analyzed. For complete details concerning the chart and its availability, contact Varian Pty. Ltd., Springvale Rd., North Springvale, Vic. 3171.

Metric Conversion News

News from the Metric Conversion Board indicates great activity in planning for metric conversion. Tangible evidence is beginning to appear in weather and tide reports, sports events and marketing of primary products. Mapping and land titles and plans in NSW are using metric units. An increasing number of books and conversion guides are appearing and the ABC will include a feature on metric conversion in the Saturday morning program "Business and Innovations". With only eleven countries in the world not yet committed to the use of metric units, and the quickening pace of planning in Australia, it is interesting that it is possible for public opposition to cause reconsideration of prescribed metric sizes for packaging of butter and margarine.

Change of Address

Hewlett-Packard Australia Ltd have announced that their Sydney office will be moving early in July to new premises in Pymble, Corner of Bridge and West Streets, Telephone 449 6566. The move has been occasioned by increased expansion in both sales activities and customer service facilities in NSW.

Elementary Particle Physics

The Nuclear Physics Sub-Committee of the Institute of Physics in collaboration with the University of Southampton is holding a Conference on Elementary Particle Physics at the University of Southampton from 12-14 September, 1972. Those wishing to receive full details and an application form should write to the Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1 8QX. The closing date for applications to attend will be 28 July 1972.

7th Thin Films Conference

The seventh Conference on Thin Films, organised by the Thin Films and Surfaces Group of The Institute of Physics in collaboration with the Atomic Collisions in Solids, Electron Microscopy and Analysis, and Vacuum Groups will be held at the University of Lancaster on 9-11 April 1973. The theme of the meeting is to be the interaction of particle beams with surfaces, and it is intended that techniques involving the use of particle beams, as well as processes resulting from beam-surface interactions shall be considered.

Offers of contributions are invited and should be sent to the Conference Secretary, B. A. Joyce, Mullard Research Laboratories, Redhill, Surrey, by 12 January
1973, together with a short (200–300 words) abstract giving title name(s) and address(es) of author(s), and reference to any previously published work on the same topic. Further details and application forms will be available in January 1973 from Meetings Office, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.

Information Services

Leslie Symes Information Services (Artarmon, NSW) is a newly formed company which aims to assist those people who require information outside their normal sphere of activity or who have only limited information resources available to them. They will conduct comprehensive literature searches or searches on highly specific subjects; obtain copies of selected articles or papers; provide a consulting service for establishing library and information services including the use of computerized techniques.

ACI Technical Centre (Waterloo, NSW) operate a computer and manual research service to supply current and backdated published literature. Services provided include bibliographies prepared on specific topics covering a specific time span; current awareness scans of items relevant to a particular client's interest profile; translations and copies; searches on the structure and products of Australian and overseas companies.

MÖSSBAUER STUDIES OF METALS AND ALLOYS

P. E. Clark

The Mössbauer effect has become an important and powerful experimental tool for the study of metals and alloys. The measurement of isomer shifts, quadrupole interactions and magnetic hyperfine interactions provides a sensitive means of determining the local distribution of electronic charge and magnetic moment at specific sites within the material. We shall be here mainly concerned with the information which can be obtained from the magnetic hyperfine interaction. The treatment will be basically qualitative, and will concentrate on experimental results obtained with the Mössbauer isotope $^{57}$Fe, partly because of the wealth of data available for this isotope and partly because the extension of the interpretation of results to other Mössbauer isotopes is relatively straightforward.

The Hyperfine Field

The Mössbauer spectrum of a nucleus is determined by its local atomic environment, and the connection between the ionic magnetic moment and the nuclear hyperfine splitting is well understood for a metal like iron. The polarized electrons in the incomplete 3d-shell exchange-polarize the inner s-shell electrons as well as the conduction electrons. The resulting unbalanced s-electron density at the nucleus results in a Fermi-contact interaction which gives rise to the hyperfine splitting. This splitting may be characterized by an effective magnetic field $H_{f}$, called the hyperfine field. Since the orbital angular momentum is quenched in iron, there is no orbital contribution to the hyperfine field. This contrasts with the rare earths— the 4f electrons which give rise to the magnetic effects are not involved in bonding and are better shielded from the environment than the 3d electrons in iron. Nevertheless, many experiments combine to show that iron atoms dissolved in transition metal matrices exhibit saturation hyperfine fields (i.e. at $T = 0$ K) of the order of 100 to 150 kOe per Bohr magneton of local moment. For the case of iron dissolved in iron, the observed field is 336 kOe and the iron magnetic moment is $2.22\mu_{B}$, so that the proportionality constant is about 150 kOe/$\mu_{B}$.

Temperature dependence of the hyperfine field.

What happens as the temperature is raised? Firstly, it must be remembered that the nucleus can only respond to fluctuations which may occur in the ionic magnetic moment provided such changes take place in a time longer than the nuclear Larmor precession time (about $10^{-9}$ s for $^{57}$Fe). In other words, the nucleus only responds to the time average $<S_{z}>$ of the $z$-component of the ionic spin $S$. But the bulk magnetization of a specimen is also a measure of $<S_{z}>$, so we might expect the temperature dependence of the hyperfine field to bear some relationship to the magnetization.

This was first checked experimentally for $^{57}$Fe by Preston et al [1962], who found that the agreement was good, though not perfect, implying that the proportionality constant mentioned above is a slight function of temperature or some other term contribute to the hyperfine field. In fact both effects are present to some degree. This now classic work also showed how the transition through the Curie point proceeds, and introduced a simple method for determining the Curie temperature, $T_{C}$. Small amounts of carbon impurity were found to broaden the transition, as evidenced by the coexistence of single line and six line spectra over a range of temperatures. Further purification reduced this effect considerably, if not completely. Also, instead of taking many spectra in the region of

$^{*}$Note: $1$ kOe = $10^{4}$/4 $\pi$A.m$^{-1}$
To they employed a technique sometimes known as a ‘thermal scan’. This involves determining the γ-ray absorption as a function of temperature, at a Doppler velocity corresponding to maximum absorption just about Tc. As the temperature is reduced the absorption abruptly decreases when the spectrum becomes magnetically split.

It should also be mentioned that reasonable agreement between hyperfine field and sample magnetization is not always obtained. Using n.m.r. of 54Mn in a sample of 1.5 per cent. Mn in Fe, Jacarrino et al [1964] found that the thermal average of the Mn moment deviated drastically from the magnetization of the Fe host. They were able to interpret this as evidence for the Mn existing in a localized state within the ferromagnetic transition metal.

Ordered Alloys and Intermetallic Compounds

In an ordered alloy or an intermetallic compound containing iron the atoms occupy a relatively small number of sites, each of which will give its own six-line Mössbauer spectrum. For instance, ordered Fe₃Al has two iron sites with magnetic moments 2.16 and 1.46μB, populated in the ratio 1:2. The Mössbauer spectrum of ordered Fe₃Al, obtained by Johnson et al [1963] shows two six-line spectra with hyperfine fields of 302 and 216 kOe, the smaller being the more intense.

If more than one phase is present the spectrum will also be complex. Again taking Fe₃Al as an example, a small amount of iron was seen to have a hyperfine field of about 264 kOe, showing that the alloy was not completely ordered.

An iron-nickel alloy containing 26 per cent. Ni has a composition close to the phase boundary at room temperature between the body-centred cubic, α-iron phase and the face centred cubic structure. The Mössbauer spectrum of such an alloy shows a broad six-line pattern corresponding to the ferromagnetic body-centred cube phase superimposed on a single line due to the non-magnetic face-centred cube component. This single line has a negative isomer shift, indicating a higher s-electron density for iron nuclei in the face-centred cube phase.

For alloys in random solid solution the iron atoms can exist in a wide variety of environments, and this is reflected in the Mössbauer spectrum by very broad lines. In more dilute alloys the number of inequivalent sites may be sufficiently reduced that each component again becomes resolved.

Dilute Alloys

Iron rich—Measurements of the magnetization of iron containing small amounts of non-magnetic impurities are consistent with the assumptions that the magnetic moment associated with the host iron atoms remains unchanged, whereas the impurity carries, at most, a moment very much smaller than that of iron. On the other hand, Mössbauer experiments indicate that the effective field of iron atoms near impurity atoms may be changed significantly (up to about 8 per cent. per nearest neighbour). One way out of this dilemma is to abandon the idea of proportionality between hyperfine field and atomic moment.

It has been found by Wertheim et al [1964] that the 3d-group elements Ti, V, Cr and Mn have effects on the hyperfine field very similar to those produced by non-magnetic impurities such as Si, Ge, Sn, Al or Ga. Apparently it does not matter whether a magnetic or a non-magnetic atom replaces an iron atom—the effect is the same, provided the magnetic atom has atomic number Z less than that of iron. It was also shown that the range of the effect of the impurity atom extends well beyond the nearest neighbour atoms.

Elements such as Co, Ni, Rh, Pd and Pt are distinctly different in that the addition of small amounts of these elements leads to an increase in the average hyperfine field experienced by the iron atoms. The near neighbour structure is not resolved but line broadening is evident, again suggesting that the effects of these impurity atoms is spread over many neighbour sites.

Dilute Iron—It would be impossible in such a short time to do justice to the tremendous amount of work carried out on dilute iron alloys, so instead we shall concentrate on one or two typical aspects of the subject. One of the most important reasons for using the Mössbauer effect in dilute alloys is the very low impurity levels which can be employed—worthwhile experiments can be conducted on samples with impurity concentrations as low as a few tens of parts per million.

When iron is dissolved as a very dilute impurity in Pd it is found by magnetization measurements [Crangle and Scott, 1965] that the total moment per Fe atom may be as high as 12μB. Mössbauer measurements on paramagnetic FePd alloys have shown how this can be interpreted in terms of a localized impurity moment polarizing the host matrix, and this form of analysis is now common in dilute alloy work.

Let us assume we can put the hyperfine field proportional to the time average value of Sₓ on the impurity atom

\[ H \propto S_\varphi. \]

In the presence of an applied field \( H_{app} \), the thermal average of the spins is given by the Brillouin function appropriate to spin S

\[ S_\varphi = S_\varphi(x) \text{ where } x = (S\mu_B H_{app})/kT \]

But suppose the iron atom having spin S is rigidly coupled to the surrounding polarized host matrix to form a complex having a total angular momentum J. Since the coupling is rigid, S must behave in the same way as J, so that

\[ S_\varphi = J_\varphi / J = B_\varphi(x) \]

where \( x \) is now \( J\mu_B H_{app}/kT \).

Since the observed hyperfine field at the nucleus is almost entirely due to the polarization of the iron core electrons (which is due to the spin S of the unpaired 3d electrons) then the hyperfine field is given as before by

\[ H \propto S_\varphi \]

or \[ H \propto S_\varphi(x) \]
In other words, the saturation behaviour (B(0) = 1) is given by S, but the approach to saturation is governed by J, which may be very large.

Mössbauer results on dilute Fe in Pd by Craig et al [1962] and Maley et al [1967] indeed show that the Brillouin function describing the behaviour in an applied field gives a total moment of approximately 12μB, but that the saturation hyperfine field of 300 kOe corresponds to only about 2μB of this being localized on the iron atom. Further work by Kitchens and Trousdale [1968] on the shape of the Mössbauer spectrum has shown that the polarization of the Pd host is approximately Gaussian, with a range such that at very low dilution about 200 Pd atoms couple with each Fe atom. A similar set of experiments by Maley and Mössbauer [1969] on very dilute Fe in Ni_{78}Ga_{22} has confirmed the validity of the previous analysis. They found a saturation field of about 220kOe, but a temperature dependence indicating an effective magnetic moment of 6μB, the largest observed to date. Also some results on Fe in Ni_{78}Al indicate that the iron can have two different environments, with different effective moments, but with almost the same saturation hyperfine field.

Other Isotopes—There are certain types of experiments in which the magnetic moment of the iron atom creates an unwanted perturbation in the system. One way around this is to use as trace impurity a non-magnetic element, such as Sn. This technique has been used by Street and Window [1966] to investigate spin density waves in chromium. Below the Néel temperature a broad distribution of hyperfine fields at the 119Sn nuclei was observed, indicating that the spin density wave was incommensurate with the lattice. When 0.8 per cent. Mn was added to the alloy a unique hyperfine field was observed, from which it could be deduced that the spin density wave had become commensurate with the lattice.

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V. I. Amassyan, L. R. Walker and G. K.
Wertheim
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C. E. Johnson, M. S. Ridout and T. E.
Graeshaw
Dilute impurities in iron
G. K. Wertheim, V. Jaccarino, J. H.
Wernick and D. N. E. Buchanan

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BOOK REVIEW
Reviewed by J. H. Piddington, National Standards Laboratory, Sydney.

Cosmology is widely accepted as a branch of physics in its own right, dealing with the origin, structure and development of the universe as a whole. In Sciama's book it is really only a focal point of a discussion of astrophysics ranging from stellar interiors to intergalactic space.

Thus Chapter 1 deals with the internal constitution of the sun and other stars, showing the relationships between mass, density, surface temperature and luminosity, and discussing the required nuclear reactions and stellar evolution. Chapters 2 and 3 deal with our Galaxy and with external galaxies, while the following four short chapters are devoted to radio galaxies, quasistellar objects and the apparent distributions of these objects. This field has been covered in a number of reviews and books, but Sciama's treatment is condensed and directed towards application to cosmological models. Nevertheless, one might question the necessity of including much of the detail, such as the history of radio astronomy back to the 1930s.

We must wait until Chapter 8 for a description of models of the universe, to which we are introduced via the Newtonian dynamics of a large gas cloud. The extension to general relativity is jolting, and it is doubtful if a reader without some prior knowledge will profit much. However, only a few pages are involved, and these are followed by a clear summary of the models. This includes formulae for parameters which relate the models to measurements made of very distant objects, such as red shifts and angular diameters. The curious cosmological coincidences are mentioned, the first being that the ratio of the radius of the universe to that of the electron, and the ratio of the electric to the gravitational force between an electron and a proton, are both numbers of order 10^{60}.

In Chapters 9 and 10 Sciama continues his discussion of astrophysics with the important question of the intergalactic hydrogen. This is followed by a discussion of the relative abundances of helium and hydrogen, which is of great cosmological significance. The final three chapters are devoted to the cosmic microwave (radio) radiation, which was predicted as a relic of the radiation of the hot 'big bang', and was first observed accidentally only a few years ago.

There are 54 clear and informative diagrams in the 203 pages of this book, followed by author and subject indexes. I recommend the book as general reading for students of astronomy and for physicists working in other areas.
THE FOURTH AINSE NUCLEAR PHYSICS CONFERENCE
G. J. F. Legge and B. H. J. McKellar
School of Physics, University of Melbourne

Between 14th February and 17th February, 1972, 144 physicists congregated in Sydney to attend the 4th AINSE Nuclear Physics Conference. Most of Australia’s nuclear and particle physicists were present, together with six from New Zealand. The University of Sydney was the host institute, and we wish to thank them for the excellent facilities they provided. We also express our thanks to the Australian Institute of Nuclear Science and Engineering for sponsoring and supporting the conference which provided a valuable opportunity for formal and informal discussions among the physicists present.

We feel that it is not our purpose to summarize individual papers—this is done admirably by the collected abstracts, a few copies of which are still available from AINSE for those who need details but were not at the conference. Instead, we will summarize current trends in nuclear physics in Australia as we gleaned them from the conference. If in voicing our biased opinion we inspire any of our colleagues to reply in kind, we will all benefit from the exchange of views.

Professor Michel Bacon of MIT gave a review paper entitled “Is there a microscopic theory of nuclear phenomena?” which provided an excellent summary of the present state of progress on the main problem of nuclear theory, namely to provide such a theory. He left us in no doubt that nuclear theorists still have a long job in front of them, since while there is a satisfactory microscopic theory of the bulk properties and single particle properties of the nucleus there is at present no satisfactory theory of many-particle phenomena, not even of the classic problem of the low-lying energy levels of the A = 18 nuclei.

The fundamental entity in nuclear theory from this point of view is the nucleon–nucleon interaction. However, it has been known for a long time that nucleon–nucleon scattering experiments do not adequately determine the interaction. In the first place one can’t adequately do neutron–neutron scattering but must extract information about it from complex situations. It was aesthetically pleasing to learn that recent data on the reaction n + d → n + n + p no longer require the inequality of the neutron–neutron and proton–proton scattering lengths. A more fundamental reason for the inadequacy of the two-body scattering data is that they do not determine the off-energy-shell behaviour of the potential. One is therefore forced to construct the potential from meson theory and to use few-body problems in an attempt to determine this property. We heard of theoretical work in both areas, as well as experiments on few-body reactions in which polarization data were obtained. A study of the reaction π + d → p + p in an attempt to obtain the same type of information was also reported.

Single particle properties of nuclei have been derived from the nucleon–nucleon interaction by the Glauber-Fock method, but this is a very time consuming process. We have heard of the construction of a phenomenological representation of the non-local Hartree-Fock potential, and a plea for more experimental studies of the single particle properties via the (p, 2p) reaction at high energies.

A similar plea for more experimental information was heard in respect of inelastic proton scattering. Here, the requirement is not for higher energies, but for precision measurements of polarization parameters at available energies. (d, p) reactions have been studied for a long time now, but they are still capable of introducing us to new effects. The conference heard that ‘two step’ processes involving core excitation are important in some reactions.

At the other pole to direct reactions lie compound nucleus reactions, which also received attention. A solution was proposed to the problem of obtaining cross sections from many-level R-matrix theory which are independent of the choice of boundary condition parameters. R-matrix theory and Feshbach theory predictions for elastic neutron scattering were compared, and the data were found to favour the R-matrix approach, which is to be expected since nuclear forces are strong compared with atomic forces for which the Feshbach theory is more suitable. The wide applicability of the R-matrix was emphasized by its use in combination with the DWBA theory of direct reactions to analyse (dp) fission through the intermediate states described by weak mixing and interference of states in the double-humped fission potential. The R-matrix model was also used to describe an example of strong mixing and the fine structure of an intermediate state seen in a (p, p’ reaction). Clear examples of intermediate or doorway-type structure, apart from isobaric analogue states, are all too rare and the theoretical predictions of both strong and weak mixing theories need much more experimental testing. It was interesting to note the almost (but not quite) total neglect of isobaric analogue states at the conference, in contrast to recent overseas meetings. This may be a fluctuation or may reflect personal interests in direct reactions and higher energies.

Heavy-ion reactions are one of the currently fashionable fields on the international nuclear physics scene, and the conference heard of their application to coulomb excitation studies, to spectroscopy of high spin states, and to the study of such special collective effects as quasi-molecular states.

In photonuclear physics, advent of the Ge(Li) detector has enabled precise determination of final states for (γ, p’) (γ, n’), (γ, α) reactions, which was
not possible from a knowledge of the particle energies yielded by bremsstrahlung radiation. This technique is important to the study of mirror reactions, isobaric analogue states and the spectroscopy of dipole states. However the low efficiency of the Ge(Li) detector and the importance of ground state reactions will ensure a need for continuing measurements of total yield. When targets are available, the inverse photonuclear reactions are more precise (which we saw in a comparison of \( (\alpha, \gamma) \) with \((p, \gamma)\) structure), but they are restricted to ground state particles and have their greatest advantage in measuring excited state gamma decay (which we did not see)—perhaps we can expect more when the ANU increase their machine energy). Continuous bremsstrahlung radiation has always provided headaches for experimenters. We note that it still does and all efforts to improve the interpretation of yield curves and remove arbitrariness in data taking and handling are to be encouraged.

Prof. M. Barranger (MIT): “Just because you get agreement with experiment, this is no proof that your theory is any good at all.”

Prof. S. T. Butler (Sydney) — Conference President

The popular hit and run method of nuclear experimentation is often forced upon us by technical considerations, but it is also often adopted as a method of increasing productivity, as measured by a publications list. Too seldom do we see the experimenter tackle a problem from several different directions and perform what might be called a complete experiment. For this reason we were impressed by a discussion of the levels of \(^{14}\)O as seen in two and four particle transfer reactions, and by a survey of keV neutron capture on several nuclei. Cross section measurements of low energy particle capture reactions of astrophysical interest were reported. This is an area where a systematic survey is required and much work remains to be done.

We found many of the more exciting papers were on experimental techniques or applied nuclear physics, a field of growing importance and relevance to industry as well as medicine. We have studied many nuclei and their interactions with penetrating radiation so assiduously for so long that it would be surprising if we could not devise sensitive techniques for non-destructive analysis of solids and for unusual tracing requirements. The New Zealand work in this field should have convinced any doubters that nuclear physics has a big role to play in such applications and future ANSSE conferences may well reflect the growing interest in and importance of such work.

The pioneering work on solid-state radiation detectors reported from Lucas Heights is most encouraging to experimentalists. The possibility of ambient temperature operation of high purity n-GaAs diodes for photon and charged particle detection also has obvious industrial significance.

The field of nuclear state lifetime measurements has received a tremendous boost from the Ge(Li) detector, and we would anticipate a further rapid growth of interest in this field as the techniques described at the conference become more widely known and available.

A very interesting series of experiments on the observation of n.m.r. through the angular correlations of the emitted radiation was reported to the conference. This yields information about the nucleus (magnetic moments, radiation mixing parameters, etc.) and its environment (e.g. hyperfine fields in the crystal) and as such is both ‘pure nuclear physics’ and ‘applied nuclear physics’—or both ‘pure solid-state physics’ and ‘applied solid-state physics’.

The devotees of particle physics in Australia are few in number, but they make up for it by their enthusiasm. Experimentalists in this field suffer a severe geographical disadvantage—they either have to carry their experiments to overseas accelerators or study such particles as they can find in the cosmic radiation. We heard of both types of experiment, including preliminary results of a quark search carried out at Auckland. One of the disappointments of the conference was the absence of any paper describing the activities of the Sydney Cosmic Ray Group.

Particle theorists do not suffer such limitations, and we heard papers on a wide variety of topics, from the Cabibbo theory of weak interactions, to duality, to the properties of the conformal group. One contribution, delivered not to the scheduled conference but to an ad hoc meeting of particle and mathematical physicists, showed that the cluster property restricts a theory of interacting parafIELDS to conserve the number of para-particles, providing a real distinction between parastatistics and Fermi or Bose statistics.

This paper was one of a number which were selected for presentation by abstract only. This system worked well at the previous ANSSE Nuclear Physics Conference, when questions were invited, and asked, on such papers. However this time these papers were ignored. Perhaps this was a consequence of the tendency of speakers this time to speak for their full 20 minutes, allowing questions only by the grace of the chairmen and at the expense of lengthening the sessions.

One of the valuable features of these conferences is that they provide a forum for the Australian Nuclear Physics community. This year the nuclear physicists decided that an organisation was required to represent their interests, and an ad hoc committee was established.
to initiate the formation of a Nuclear and Particle Physics group. Suggested activities of the group included circulation of a newsletter, and the holding of summer schools or topical conferences, to supplement the overall survey of nuclear physics provided by these AINSE conferences.

All conferences generate discussion on ways in which they may be improved and this was no exception. A lively closing discussion on these points was held and conflicting viewpoints emerged. There was a plea for more invited review talks to educate the audience. There was a plea that graduate students need the conference as an arena for developing their conference. A pleasing feature of the conference was the generally high quality of papers contributed by graduate students, who set an example to their elders in the care with which they prepared their contributions, which in many cases also benefited from a pre-conference presentation before a critical audience. Perhaps we can invite graduate students to give the review talks at the next conference.

### METRIC UNITS

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<th>Symbol</th>
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<td>ampere</td>
<td>electric current (SI base unit)</td>
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<td>angstrom</td>
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### Typographic

- **3517.7938 m**
- **103 517.793 863 Hz**
- **0.473 121 N·m or N·m s⁻¹ or m/s**
- **kg/(s²·K) or kg·m/s²·K⁻¹**
- **kg/m³ not mg/cm³ cm³ = 10⁻⁶ m³**

### SI and units accepted for use with SI

**Units to be used with SI for a limited time**

**Additional units at present retained for use in Australia (AS 1000)**

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PHYSICS IN TECHNOLOGY

There is among physicists in Australia a growing awareness of, and interest in, the applications of physics to technology. In accordance with this trend it is planned to include in The Australian Physicist, a new section entitled

Physics in Technology

This section will deal with any new technological developments in Australia in which physics plays some part. Some of these developments may be new instruments or new applications of instruments but it is intended that the bulk of the material will deal more directly with the physical principles involved in technology.

Contributions to this section will be welcome and should be sent to the Editor, Australian Physicist.

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