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General—Manuscripts submitted for publication should take, in general, one of three forms:

An Article on matters of interest to physicists, including selected lectures given at Institute, Branch or Group meetings.

A Letter to the Editor on matters affecting physicists or on articles and letters previously published. In general, letters should not exceed 1000 words.

Notes and News may include Institute activities, announcements to members, comments and announcements by overseas Institutes of Physics and other local scientific bodies. In general, the text should not exceed 400 words. Abbreviated notices of meetings may be submitted for The Calendar.

In preparing manuscripts, contributors should follow the general style used in this journal. Manuscripts should be double space typed on one side of the paper only and with side margins one and a half inches wide. Every page, including those with tables and illustrations, should be numbered. For an Article, the author’s name should appear underneath the title, followed by the address of the laboratory. For a Letter to the Editor, the author’s name should appear at bottom right, and his address and the date at bottom left of the letter.

The original typescript and one copy should be forwarded. Original drawings should be submitted but, where possible, photographic copies, Xerox, or blueprints of the originals should also be submitted. Half-tone illustrations should only be included if essential; they should be on white glossy paper and show a full range of tones with good contrast.


References are to be cited in the text by year of publication, e.g., Brossel [1947], and are to be arranged alphabetically at the end of the article, giving author’s name and initials, followed by year of publication. For journal articles, this is followed by the title of periodical, volume, and page, thus:


Abbreviations of titles of periodicals should conform to those used in A World List of Scientific Periodicals; please consult this.

References to books should give the author or editor, year of publication, title, number of edition, town of publication, and publisher’s name.


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Australian Institute of Physics

RADIATION DAMAGE CONFERENCE

School of Physics, University of New South Wales

8-11 February 1972

A conference on radiation damage in solids, sponsored by the Australian Institute of Physics, is to be held in Sydney, 8-11 February 1972.

Programme
Invited and contributed papers on:
(a) Theories of irradiation damage by neutrons and charged particles.
(b) Effect of damage on the mechanical properties of solids.
(c) Effect of damage on transport properties.
(d) Experimental techniques including diffraction, microscopy, and channelling.

Speakers from overseas will be attending.

Preliminary abstracts of contributed papers should be submitted by 15 November 1971.

Accommodation
Accommodation is available at Goldstein College for $9.00 per day full board, or $5.50 bed and breakfast.

Registration
The conference fee will be $20.00 with concessional rates for students. This fee includes the conference dinner.

APPLICATION FORM

To be returned to: Dr C. J. Howard, Conference Secretary
Australian Atomic Energy Commission
Research Establishment,
Private Mail Bag, Sutherland, N.S.W. 2232,
by 15 November 1971.

Name: ...........................................
Address: ...........................................

I wish to attend the Radiation Damage Conference and enclose cheque/money order/postal note for the $2.00 conference deposit.

I intend to submit a paper and enclose title/abstract.

YES ☐ NO ☐

I wish to reserve accommodation in Goldstein College for ............... persons for the period from ........../2/72 to ........../2/72, and enclose a further $5.00 as deposit

YES ☐ NO ☐

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.
NEW ENERGY-CONVERSION DEVICES BASED ON THE NERNST AND ETTINGSHAUSEN EFFECTS

H. J. Goldsmid
School of Physics, University of New South Wales

During the past twenty years there have been quite impressive developments in the use of thermocouples as energy converters. These developments, resulting from research on semiconducting materials, have made thermoelectric refrigeration a useful technique, at least in laboratory work, and thermoelectric generators have been employed in several specialist applications.

Just over ten years ago, O’Brien and Wallace [1958], working at the University of Sydney, pointed out that the transverse thermomagnetic effects could, like the thermoelectric effects, be used in energy conversion. Since that time there has been quite a substantial effort devoted towards the improvement of thermomagnetic materials. Unfortunately, refrigeration or generation based on the thermomagnetic effects is still far from practicable. Work on thermomagnetic materials is continuing and I am confident that substantial improvements will be made in the not-too-distant future. However, my present intention is to describe devices that can be made with present-day materials.

The thermoelectric effects (the Seebeck and Peltier effects) are familiar to almost all physicists but the thermomagnetic effects are not nearly so well known. The Nernst effect is a transverse electric field that results from a longitudinal flow of heat in a conductor that is placed in a mutually perpendicular magnetic field. The Ettingshausen effect is manifest as a transverse temperature gradient resulting from a longitudinal flow of current, again in a transverse magnetic field. Thus the Nernst effect is the transverse analogue of the Seebeck effect, while the Ettingshausen effect is more or less the transverse counterpart of the Peltier effect. The transverse effects have the disadvantage that a magnetic field is necessary for their demonstration. On the other hand, they need only one type of material, whereas the longitudinal effects require pairs of materials, i.e. thermocouples.

Thermomagnetic Materials

It is not my intention here to give a detailed discussion of thermomagnetic materials. However, a brief outline of the principles upon which they are selected seems to be in order. In the first place, a high carrier mobility is desirable when one is making use of any transverse phenomenon, whether it be thermomagnetic or galvanomagnetic, i.e. the Hall effect. Furthermore, in order that the Joule-resistance heat losses may be minimized, it is necessary that the electrical conductivity should be as high as possible. Also, since heat conduction is an irreversible process, the thermal conductivity of the material should be as small as possible.

The thermomagnetic effects can originate in two different ways. Thus, consider figure 1(a), which shows a current flow in a conductor which has a single type of carrier, in this case electrons. When a magnetic field is applied, the Lorentz force tends to move the electrons sideways but, of course, the boundary conditions prevent any transverse flow of charge when equilibrium is established. In other words, a Hall field is built up which opposes the Lorentz force. In actual fact, since the electrons do not all have the same drift velocity, some of them will have a transverse flow in one direction, this being balanced by a transverse flow of the others in the opposite direction. These flows, depending on the fact that the relaxation time varies with electron energy, imply that heat is transferred from one side of the sample to another, thus establishing the Ettingshausen temperature gradient. If this effect is to be large it is necessary that the relaxation time should show a very strong dependence on energy.

![Figure 1](attachment:image.png)

Figure 1

Origin of the Ettingshausen effect in (a) a conductor with one type of carrier and (b) an intrinsic conductor.

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Figure 1(b) shows the alternative origin of the Ettingshausen effect. In this case there are two types of carrier, electrons and holes, and it is seen that the Lorentz force tends to drive them both in the same direction. Since the two carriers are of opposite sign, the transverse flow in this case does not imply any net charge transfer. In other words, the electrons and holes are free to carry their ionization energy from one side of the material to the other. As one might expect, the Ettingshausen temperature difference is generally largest when this bipolar transport can occur. Unfortunately there are few materials in which the holes have a mobility that is sufficient to match that of the electrons. If there is only one type of carrier, or if the holes are immobile compared with the electrons, is advantageous to provide a means of short-circuiting the Hall effect. This can sometimes be accomplished by the provision of external metallic strips or by suitably oriented metallic inclusions.

The above principles are exemplified by the materials that we have been investigating at Kensington. Generally, the energy-conversion efficiency can be expressed by a quantity known as the thermoelectric figure of merit which is defined as $Q^{10}$, where $Q$ is the Nernst coefficient, $B$ is the magnetic induction, $\rho$ is electrical resistivity, and $S$ is the thermal conductivity. At low temperatures, or when a very large magnetic field is available, there is no doubt that bismuth and certain of its alloys have the highest figure of merit. This is because bismuth has electrons and holes which are both extremely mobile. At room temperature in a more modest magnetic induction (less than 1 tesla) other substances are superior. Weiss and his colleagues at Siemens in Germany have developed a eutectic material based on the semiconductor indium antimonide in conjunction with the metallic conductor nickel antimonide [Wagner and Weiss, 1965]. The Ni$_3$Sn$_2$ inclusions in the InSb matrix, aligned perpendicular to the current flow and the magnetic field are an effective means of short-circuiting the Hall voltage. We have found that another semiconductor compound, cadmium arsenide, has a comparable figure of merit to that of InSb-Ni$_3$Sn$_2$ at room temperature in a modest magnetic field, and is superior for some applications. The virtue of indium antimonide is its very large electron mobility, higher than that of any other known conductor. Cadmium arsenide is effective because it has a moderately high electron mobility with a strong dependence of the relaxation time on electron energy; the thermal conductivity due to the lattice vibrations in cadmium arsenide is also extremely small.

A Fast Thermal-Radiation Detector

In spite of the development of photoconductive devices with a higher detectivity, the radiation thermopile still remains an important infrared detector. It is an absolute instrument and can be used at all wavelengths; furthermore, it does not need to be refrigerated. However, it suffers from a very serious disadvantage. It is common practice to chop the incident radiation so that the detected signal can be fed into an amplifier that is tuned to the appropriate frequency. The chopping frequency is limited if the detector is a radiation thermopile because of its inherently rather slow response. Comparatively fast thermopiles were developed by Schwarz [1952] employing most ingenious methods of construction but, even so, the response falls off rapidly at chopping frequencies in excess of a few tens of hertz. It is in this context that the thermoelectric radiation detector becomes important.

The transverse electric field due to the Nernst effect is proportional to the longitudinal temperature difference so much as to the temperature gradient. Thus, for a given flow of thermal energy through the material, the Nernst voltage is independent of the thickness of the sample in the direction of the flow. On the other hand, the Seebeck voltage in a thermocouple is proportional to the temperature difference, which does depend on the thickness. To a first approximation the response time of a thermal detector is proportional to the square of the thickness between the receiving surface and heat sink. It is, then, apparent that extremely small response times can be achieved for a radiation detector based on the Nernst effect.

The detector is extremely simple. It can consist merely of a thin sheet of a suitable conductor with electrical contacts attached to its ends. A sheet is attached via an electrically insulating cement to a heat sink and the front surface is blackened. The conductor is placed between the poles of the magnet shown in figure 2. The performance of such a detector using a bismuth element has been described by a group of workers at the Lockheed Palo Alto Research Laboratory [Washwell et al., 1970]. These workers point out that the so-called detectivity is much less dependent on response time for a Nernst detector than it is for other types of thermal detector. Thus, at a high enough chopping frequency the thermoelectric device always appears to be the best thermal detector. For example, the bismuth device in a magnetic induction of one tesla was superior to a thermistor bolometer (claimed to be the fastest commercially available thermal detector) for a
response time of less than 0.1 s at 200 K or less than $4 \times 10^{-4}$ s at 300 K.

At room temperature in smaller fields, an even better performance can be obtained if the detecting material is InSb–NiSb [Paul and Weiss, 1968] or Cd$_3$As$_2$ [Goldsmid and Sydney, 1971]. Commercial detectors based on InSb–NiSb are available and some idea of their sensitivity can be gauged from the claim that they have been used to detect the presence of a person at a distance of 80 metres using a 4-centimetre parabolic mirror to concentrate the thermal radiation. There is no doubt, then, that the Nernst detector is already an important device.

Direct-current Transformers

A few years ago my interest was aroused by the report of a direct-current transformer that made use of the magnetic coupling between superconducting films. In a comment on the report it was conjectured that this was the first time that a true direct-current transformer had been produced. This turned out not to be true, since a few years earlier Shockley had described such a transformer based on the so-called transferred phonon-drag effect. However, both these transformers were essentially low-temperature devices and it occurred to me that a room-temperature transformer based on the thermoelectric effects could easily be made.

The principle of the transformer is shown in figure 3. The device consists of two thermopiles placed in thermal contact with one another and having a common heat sink. When an electric current is passed through one of the thermopiles a temperature difference, due to the Peltier effect, is produced. This temperature difference, applied to the second thermopile, gives rise to a Seebeck e.m.f. One can obtain multiplication of either current or voltage by a suitable selection of the numbers of thermocouples in the two thermopiles. Thus, by having 48 couples in the secondary thermopile and one couple in the primary thermopile, I was able to observe an open-circuit voltage multiplication of about 9 to 1 [Goldsmid, 1966].

All the direct-current transformers that have been reported are low-efficiency devices so one can hardly envisage them playing the same ubiquitous role as a.c. transformers. Nevertheless, there may be worthwhile applications in instrumentation. For example, it could be useful to voltage-multiply a very small d.c. signal from a low-resistance source before feeding it into a conventional amplifier. However, a thermoelectric transformer suffers from the disadvantage of a relatively long time constant.

The thermomagnetic effects provide an alternative means of achieving the direct-current transformer function and, moreover, they enable the response time to be reduced by many orders of magnitude. Figure 4 shows the essential components of a thermomagnetic transformer. Under the action of the transverse magnetic field the electric current through the primary element produces a transverse temperature difference through the Ettingshausen effect. This temperature difference, acting on the secondary element leads to a Nernst e.m.f.

It is interesting to consider the essential features of a true direct-current transformer that are displayed by this thermomagnetic device. There is electrical insulation between the primary and the secondary. The output e.m.f. is strictly proportional to the input e.m.f. and changes sign with the latter. Also, the transformer is a completely passive device.

Since the Nernst e.m.f. depends strictly upon the temperature gradient in the secondary rather than the temperature difference, it turns out that one can achieve voltage multiplication just by making the thickness of the secondary much less than that of the primary. However, it is difficult to achieve voltage multiplication in this way and at the same time have a very small time constant. An alternative way of multiplying voltage is to make the secondary much longer than the primary. If the materials can be prepared by thin-film techniques, it should be possible to adopt the arrangement shown in figure 5. Here the primary consists of a single cylindrical sheet while the secondary consists of a long spiral.

Finally I would like to mention an interesting combination of the thermoelectric and thermomagnetic transformers which I have called a hybrid transformer. Here, as shown in figure 6, the primary consists of a thermocouple or thermopile while the secondary is a thermomagnetic element. This combination makes
use of the Peltier effect to produce the temperature difference and the Nernst effect to give an output e.m.f. The primary, consisting of bismuth-telluride thermoelements, is insensitive to the application of a magnetic field whereas, of course, the output e.m.f. from the thermomagnetic element does depend on the field strength. Thus the voltage multiplication is more or less proportional to the field and the device behaves as a variable direct-current transformer. From the practical point of view the hybrid transformer is little more than a laboratory curiosity. However, its principle can be usefully employed in comparing different thermomagnetic materials. In this way we have demonstrated that the bismuth alloys are generally the best materials at low temperatures while InSb–NiSb and Cd₃As₂ are the best room-temperature materials if the magnetic induction is less than 1 tesla.

Conclusions
I hope that I have been able to demonstrate that the thermomagnetic effects have interesting and novel applications. The radiation detector is already a worthwhile device and could become even more attractive as improved materials are developed. The thermomagnetic transformer provides a novel way of performing an unusual function. I am certain that, as time goes by, other applications of the thermomagnetic phenomena will be revealed.

Acknowledgement
Figures 3, 4, 5 and 6 have been previously published and are republished here with the permission of the Institute of Physics and Physical Society.

References

THE CALENDAR

October
25–26 Third AINSE Conference on Radiation Biology; Lucas Heights, NSW.
28-29 Nineteenth Council Meeting; Melbourne (AIP).

November
9 Annual General Meeting, Sydney Uni. (NSW–AIP); Physics in Meteorology, V. J. Bahr, Bureau of Meteorology.
20– Annual General Meeting (ACT–AIP)

December
14 Irrigation, Sydney Uni. (NSW–AIP, Annual Dinner); Dr B. R. Davidson, Dept of Agricultural Economics, Sydney Uni.

January, 1972

February
8–11 Radiation Damage Conference, Uni. of NSW (NSW–AIP); (See AP, May 1971).
28– Second Vacuum Symposium, SAIT, Adelaide; (AIP– Vacuum Group; see AP, May 1971).

March
14 Photons and Stars, Pawsey Memorial Lecture, (NSW–AIP); Prof. R. Hanbury Brown, Sydney Uni.
POSTGRADUATE TRAINING

Edited by J. R. Bird and G. R. Hogg
A summary of opportunities for higher degree studies, prepared at the suggestion of the NSW Branch Committee.

INTRODUCTION

There is now a considerable choice within Australia, of research centres and topics for higher degree studies. The following summaries have been prepared by University Departments and give some idea of the opportunities available. However, the short time available to collect this information for publication before the end of the 1971 academic year has mitigated against completeness and uniformity of presentation. It is hoped that it will prove useful in its present form. Additional information is contained in 'Scientific and Technical Research Centres in Australia' published by the CSIRO in 1969.

AUSTRALIAN NATIONAL UNIVERSITY

Institute of Advanced Studies, Research School of Physical Sciences

Applied Mathematics, Prof. B. Ninham

This new Department is concerned initially with the applications of physical theories to the quantitative understanding of biological systems. Additional lines of research will be developed in areas involving interactions with other Departments in the Research School.

Astronomy, Prof. O. J. Eggen

The Department operates the Mount Stromlo and Siding Spring Observatories. The main lines of research are the physics of stellar atmospheres, evolutionary problems, especially as they can be studied in clusters and in the Magellanic Clouds, external galaxies, radio sources, and galactic structure. Facilities exist for high dispersion spectroscopy, spectroscopy of faint objects, photometry, especially of faint objects, spectral scanning, and polarization measurements. Theoretical work is currently being done in the fields of stellar interiors and stellar evolution.

Engineering Physics, Prof. S. Kanoff

Research involves experiments making use of the unique features of a large homopolar generator energy store (576 megajoules) which can supply very high current pulses (up to $1.6 \times 10^8$ amperes) and power rates of over 500 megawatts. Currently, research is being conducted in the production of very intense magnetic fields and magnetic fields of special characteristics, high power lasers and non-linear optics, macroparticle and gas acceleration, and the study of electric arcs. Related studies include those on phenomena associated with moving electrical contacts at speeds and current densities well beyond normal, transient measurements on highly stressed bodies moving at high speeds, and the control of very high currents and powers. Other work involves the study of hot plasmas and novel work in artificial intelligence, particularly pattern recognition and man-machine communication.

Geophysics and Geochemistry, Prof. J. C. Jaeger

This Department carries out work in the fields of igneous and metamorphic petrology, structural geology, trace element geochemistry, cosmochemistry, isotopic age determination, geomagnetism and paleomagnetism, seismology, heat flow, phase equilibria, and deformation of rocks and minerals at high pressures and temperatures.

Nuclear Physics, Prof. J. O. Newton

Research in nuclear structure physics involves work with a 12-MeV tandem accelerator and a 2-MeV electrostatic generator. The tandem accelerator has recently been provided with a high-intensity polarized ion source and a 24-MeV cyclotron injector will be installed in 1971. A new tandem accelerator with a 14-MV terminal which will be the largest of its type in the world, will be installed in 1972 and is expected to come into operation early in 1973. The accelerators are supported by modern detecting equipment including a 24-in double focussing spectrometer and a Buechner spectograph together with data-processing systems including an IBM 1800 computer on line to an IBM system 360/50.

Solid-State Physics, Prof. W. A. Runciman

This new department will centre its research around the 70-kG super conducting magnet and the pulsed 165-kG and 300-kG systems which have been built in the Department of Engineering Physics. In the course of time research programmes involving spectroscopic techniques will be developed in the area of biological and earth sciences.

Theoretical Physics, Prof. K. J. Le Couteur

Theoretical aspects of nuclear physics, high energy physics, many body problems, statistical mechanics, and plasma physics. A fast electronic computer is installed in the School.

Electron and Ion-Diffusion Unit and Diffusion-Research Unit

In addition the School has two Units. These are: the Electron and Ion-Diffusion Unit which works on collision processes of electrons and ions in gases; and the Diffusion-Research Unit which is engaged in theoretical and experimental research on cryogenic and other liquids with emphasis on tracer-diffusion studies, including work at high pressures.

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School of General Studies, Physics Department, Prof. S. Hinds

Aerophysics

Research is conducted in the dynamics and kinetics of hyper-velocity gas flows, the production and properties of strong shock waves and the study of electromagnetic ionizing shock waves. Four free-piston shock tubes are available together with associated support equipment.

Laser Physics

This work is concerned with fundamental processes in gas lasers, particularly energy transfer in collisions of the second kind. Optical and spectroscopic investigations using lasers are also carried out.

Nuclear Physics

Research is concerned with the structure of atomic nuclei and experiments are performed with a accelerators in the Institute for Advanced Studies.

Solid-State Physics

Atomic collision in solids produced by bombardment with ions are studied with a 30-kV inert-gas ion source and a 100-kV accelerator. Atomic diffusion in solids is studied using radioactive tracers to follow the movement of the diffusing atoms. A complete range of high-temperature furnaces and counting equipment supports this work.

University and Commonwealth Postgraduate Scholarships may be applied for and initial inquiries should be directed to the Head, Department of Physics, Australian National University.

Theoretical Physics Department, Prof. H. A. Buchdahl

This Department carries out work mainly in the fields of plasma astrophysics, quantum theory, general relativity theory, and optical aberration theory.

THE FLINDERS UNIVERSITY OF SOUTH AUSTRALIA

School of Physical Sciences

There are three physics research groups in the School. The interests of the groups overlap so that members collaborate with each other, as well as with members of other groups in Australia and overseas. Research students are required to take several graduate courses (and in some cases honours courses to make up deficiencies in background). Detailed information on the research work of the School is contained in the Annual Report, a copy of which will be mailed on request.

Atomic Physics, Prof. H. A. Blewitt

Atomic Collision Processes: electron scattering from atomic hydrogen and other atoms.

Kinematically complete ionization measurements: the (e, e2) reaction on atoms and molecules.


Gas breakdown and ionization: high-voltage breakdown in crossed fields; effective Townsend ionization coefficients.

Plasma Physics, Prof. M. H. Breman

Shock waves: ionizing shock fronts; large-amplitude waves.

Wave propagation: helicon waves; ion cyclotron waves; effects of non-uniformities; anomalous skin effect in plasmas; scattering of microwaves from non-uniform plasmas.

Diagnostics: laser and microwave techniques; spectroscopy.

Facilities include three large plasma sources plus associated diagnostic equipment, microwave interferometers, monochromators, gas and high-power ruby lasers.

Theoretical Physics, Prof. I. E. McCarthy

Nuclear theory: investigation of nuclear structure and forces by reactions; scattering theory; nuclear structure theory.

Atomic theory: investigation of atomic and molecular structure by atomic beam scattering and reactions.

Many-body theory: statistical mechanics; transport properties of fluids; quantum many-body problem.

Facilities include access to a CDC 6400 computer.

More students are needed and may be eligible for University and Commonwealth Scholarships. Stipends are normally supplemented by six hours per week of laboratory supervision or the equivalent.

JAMES COOK UNIVERSITY, NORTH QUEENSLAND

Physics Department

The major research activities fall into the categories of radio physics and atmospheric physics. These are supplemented by some specialized studies in low-energy nuclear physics based on the facilities made available by AINSE; and by solid-state experiments related to the examination of molecules by polarized electron beams and more generally to crystal-dislocation phenomena. Some theoretical physics is encouraged, some design in precise physical instrumentation is in progress, and the relationship of various physical principles to tropical environments is regarded as a matter for constant attention.

The radio physics covers anomalous trans-equatorial propagation, coherent radar backscatter from ocean waves, aerial array design, and the morphology of equatorial radio noise. A large aperture, continuous azimuth scan, h.f. array is available.

The atmospheric studies are fostered by the Tropical Research Unit for Meteorological and Atmospheric Physics (TRU MAP) which has the encouragement of the CSIRO and the Bureau of Meteorology.

Twelve graduates are proceeding to higher degrees either full time or part time at present. Graduates with good honours degrees in physics and mathematics can still be considered for higher-degree studies but they would need to hold their own scholarships. A limited amount of demonstrating time can be allocated.
MONASH UNIVERSITY
Department of Materials Engineering

A Department of Materials Engineering was established at Monash University in 1970 from a Materials Science Group. An undergraduate course in Materials Engineering was introduced in 1971 and the department has research activities relating to metals, plastics, and ceramics. Currently there are six members of the academic staff, two research fellows, together with twelve postgraduate scholars who are undertaking research projects leading to degrees of Master of Engineering Science or Doctor of Philosophy. Because of the interdisciplinary nature of materials research, postgraduate study in materials engineering can be entered from a variety of undergraduate courses and five of the current research scholars have basic qualifications in physics.

Most current research is concerned with relationships between the structure and properties of materials and topics include: deformation and yield in plastics, strength and fracture toughness of fibre-reinforced composites, mechanism of adhesion of thermoplastics, trace-element effects in age-hardening alloys, ceramic powders produced by high-temperature plasma methods, mechanism of abrasion of ceramics, stress-relief cracking, fatigue, toughness, and thermal fatigue in alloy steels, mechanics of metal rolling, electrical resistance of polymeric insulators, and frictional properties of elastomers.

Postgraduate scholars are financed by Commonwealth Postgraduate Awards, Monash Graduate Scholarships, and by scholarships provided by industrial firms and government departments. A limited number of these scholarships will be available in 1972, which will be awarded according to the merit of the candidates. Applications for CPA and MGS awards in particular should be made by 31 October 1971.

Further information may be obtained on request to the Chairman, Department of Materials Engineering, Monash University, Clayton, Vic. 3168.

Department of Physics

The department provides graduate training in a variety of fields leading to the degrees of MSc and PhD. Current interests include:

Experimental Physics

Magnetic phase transformations, Mössbauer effect in alloys, nuclear orientation, hyperfine interactions in rare earth alloys, magnetic properties of rare earth compounds, n.m.r. of ferromagnetic metals, magnetic ordering in solids, electron-spin resonance, anti-ferromagnetic resonance, transport properties of ^3He and ^4He solutions, thermodynamic properties of solids at low temperatures, superconductivity (the influence of structure), polymer physics, non-linear optics, photo-count distributions, superradiance, laser spectroscopy, optical studies of defects in transparent crystals, solid-state geophysics, optical astronomy, electron-photon cascades.

Theoretical Physics

Statistical mechanics and phase transitions, magnetism in alloys, coupled electronic and nuclear spin systems in ferromagnets, properties of transition metals and alloys, Kondo effect, electron band theory, electron states in disordered potentials, plasma physics, quantum electrodynamics, foundations of quantum mechanics.

Research Facilities

Helium liquefier, dilution refrigerator, high resolution X-ray diffraction and spectroscopy facilities, electron microscope; helium-neon, argon-ion, ruby, neodymium-doped glass, and gallium arsenide lasers.

Digital computing facilities are available including a machine shop, precision workroom, electronics workshop, photographic laboratory, materials-preparation laboratory.

A limited number of scholarships is available each year (University, Commonwealth, AINSE, CSIRO); the usual minimum requirement being an upper-second-class honours degree. Inquiries concerning scholarships should be directed to the Scholarships Office, Monash University.

Further information together with copies of the booklet 'Physics at Monash' may be obtained from the Chairman, Department of Physics.

UNIVERSITY OF ADELAIDE
Department of Physics

Space Physics

This work is mainly in the field of vacuum-ultraviolet physics and is concerned with rocket-borne and satellite experiments and related laboratory studies. Observations of the absorption of u.v. radiation by the atmosphere are carried out and absolute solar fluxes are determined. The Department is well equipped for laboratory studies in vacuum-ultraviolet physics and the laboratory programme is concerned principally with studies of photo-ionization and photo-absorption in gases, particularly those of atmospheric and astrophysical interest. Particular attention is being given to the method of photo-electron spectroscopy, which provides much more detailed information than can be obtained from total photo-ionization cross-sections alone.

Radio Physics

This group is engaged in work on meteor physics, ionospheric physics, radio astronomy, and atmospheric scattering of laser light. Radio observations of ionized trails formed by meteors are carried out using a 27-MHz Doppler radar system. For ionospheric work, a large aerial array 1 Km in diameter is available at the Buckland Park field station, 25 miles north of Adelaide. This is used at present mainly to study ionospheric irregularities and movements. In radio astronomy, the main line of work involves the study of the scintillations of quasars produced by irregular plasma streams flowing from the
sun. Scattering of laser light is studied using a pulsed ruby laser; the experiment gives information about the concentration of particulate matter in the atmosphere.

**Cosmic-ray Physics**

The cosmic-ray group has a continuing interest in X-ray astronomy using balloons and rockets, the latter in collaboration with the University of Tasmania. The programme is directed at exploiting our southern hemisphere location to view, for example, the Centaurus-Crux region which seems to contain a number of unusual variable X-ray sources.

A new project has begun to study the radio signals generated by extensive air showers with the object of determining the composition of primary cosmic rays in the energy region above $10^{16}$ eV.

**Solid-State Physics**

Research work in solid-state physics includes the optical properties of thin films, thermoluminescence of molecular solids, fluorescence of organic crystals, and accurate X-ray structure analysis of some metal crystals.

**Seismology**

A network of seven seismograph stations in South Australia are providing information on the location, magnitude, and frequency of occurrence of earthquakes in South Australia. As the pattern of epicentre locations becomes clearer, attempts are being made to correlate these with major geophysical and geological features. Recordings of large quarry blasts are also providing information about crustal structure.

Research students normally attend some of the Honours Lectures, which cover quantum mechanics, electromagnetism, experimental methods, thermal physics, fundamental particles, nuclear physics, solid-state physics, Fourier methods, atmospheric physics, astrophysics, and atomic and molecular physics.

Research students normally hold either CSIRO, Commonwealth, or University Research Scholarships. Details can be obtained by writing to Prof. J. H. Carver, Department of Physics, University of Adelaide. About ten new research students would be acceptable in 1972.

**UNIVERSITY OF MELBOURNE**

**School of Geology**

A Geophysics Group gives courses in geophysics at 3rd year undergraduate level, for Honours degree, and also offers postgraduate training facilities. Interests in the Group include marine geophysics (in co-operation with the Hawaiian Institute of Geophysics); observatory seismology (strainmeter, local earthquake studies); crustal physics (deep resistivity, gravity, magnetic techniques). The Honours course 1972 will take 4–6 students, and vacancies for higher-degree students may be available; applications will be given full consideration.

**Metallurgy Department**

In the field of physical metallurgy the major effort is on the study of the relation between macroscopic properties and the atomic-defect structure. This approach is being applied, for example, to the study of the role of crystal boundaries in the creep of metals, i.e. the continued plastic flow which occurs under constant stress at elevated temperature. The same approach is being applied to the study of the defect structure of a number of simple alloy systems whose properties can be controlled by different thermal treatments. These alloys are being examined by electron diffraction and electron microscopy.

The field of mechanical metallurgy has been neglected somewhat by physicists but offers great scope for a combination of experimental skill and facility in applied mathematics. The work in the department is concerned mainly with the rheology of the rolling process. Other projects in the department include theoretical and experimental studies of point defects in metallic crystals, irradiation damage in alloy crystals, and precipitation in steels.

Excellent facilities exist for mechanical testing and for analysis. The department has fairly complete metallographic facilities—optical electron and field-ion microscopy—and access to a scanning microscope and a probe analyser.

**School of Physics**

**Nuclear Physics**

Nuclear physics is pursued by a large and active group in the department, which pioneered Australian work in this field. Experimental work is carried out on the department’s 3 accelerators—Betatron, Cyclotron, and Statatron—and on the AABC Van der Graaff accelerator and reactor at Lucas Heights. Beams of photons, neutrons, protons, deuterons, and alpha particles are available and equipment includes on-line computers. Current research interests include the giant dipole resonance, intermediate and isobaric analogue states, pickup, stripping and other direct reaction, neutron-capture spectroscopy, and nuclear astrophysics.

**High-Energy Physics**

The high-energy physics group carries out experimental and theoretical research on the ‘elementary’ particles and their interactions with each other at very high energies. The experimental method being used at present is the observation and measurement of particle interactions in bubble chamber; photographs taken by group members at overseas accelerators are brought back to Melbourne for measurement and analysis, using manual measuring machines and the automatic machine ‘Sweepnik’. Theoretical work covers a broad range of interests but there is special emphasis on strong interaction theory and the use of Regge pole methods in the interpretation of experimental data.

**Diffraction Physics**

An important part of the research work is devoted to the development of new experimental and theoretical techniques for the study of the scattering of electrons, X-rays, and neutrons by crystals. These techniques are also applied to the study of crystal structures and crystal
defects and a variety of problems in solid-state physics in which structure plays an important role. Two commercial electron microscopes and a 600-kV scanning transmission electron microscope are available. X-ray equipment includes two four-circle single-crystal diffractometers and monochromators. Neutron work uses AAEC facilities at Lucas Heights.

Theoretical Physics

In Theoretical Physics research is in the following main areas:
- nuclear and atomic physics—collision processes, shell structure, nuclear matter;
- plasma physics—the test-particle problem and nonlinear plasma problems;
- statistical mechanics—phase transitions and cooperative phenomena;
- high energy physics—S-matrix theory of strong interactions.

A CYBER 72 computer and an IBM 7044 computer are available. Commonwealth Grants and University Grants are available in limited numbers. Vacancies exist for up to 25 research students within the School in 1972.

Physics (RAAF) Department

The work of this department is in three main research fields: ionospheric physics, meteorology, and astronomy.

The ionospheric work is mainly centred on a combined study with New England University of partial reflection and wave interaction using the powerful transmitter at Armidale. The meteorological studies are now concentrating on the measurement of the refractive index of the air using acoustic sounding techniques. The analysis has much in common with structure studies of the ionosphere. Astronomical studies involve ground-based and balloon-based searches for infrared sources. The Mt Stromlo 50-inch telescope has been used for some of the ground-based work. Other astronomical balloon experiments involve the search for gamma-ray radiation from galactic and extragalactic regions. The infrared astronomy work is carried out in collaboration with University College, London and the gamma ray astronomy program is in collaboration with Case Western Reserve University, Cleveland, Ohio. Infrared techniques are also being developed for atmospheric studies.

The research laboratory is in the University grounds, Carlton. Vacancies exist for three students in 1972. For further details write to Prof. V. D. Hopper, Physics Annex, University of Melbourne.

UNIVERSITY OF NEWCASTLE

Physics Department

The Department welcomes research students with a good undergraduate degree. Postgraduate scholarships are probably not yet as difficult to obtain as in the big universities, and an Honours First will certainly, or a Second, Division 1, will often secure such an award.

There is particular strength in electronics in the Department, and sophisticated instrumentation is built and used in many of the research projects. It concentrates on spectra and surface physics in the pure physics area, and specializes heavily in geophysics, ranging from the magnetosphere, through the ionosphere, to earth problems of combined physical and geological interest.

Seven research areas can be identified, as follows.

Infrared

The Department operates the only airborne far-infrared scanner in any Australian University. It is used within the Department to develop improved detection methods, and has been flown extensively in Australia and New Guinea to study areas of particular geologic and hydrologic interest. New interpretation techniques, both photographic and electronic, have been devised. Considerable instrumentation had previously been developed for the automated detection of very weak signals buried in noise. This equipment is now being developed to give computer-evaluated temperatures from the far-infra-red information recorded on magnetic tape.

Spectroscopy

Work continues on measurement of the temperature of plasma by studies of the spectra of highly excited iron atoms.

Surface Physics

The following lines are being actively pursued: the study of electron emission from aluminium deformed in tension, the study of the interaction of oxygen with clean aluminium single crystals, and the building of the secondary electron spectrometer.

Atomic States

Lifetimes of excited states of atoms in the nanosecond range are being investigated.

Ionospheric and Space Physics

There is a considerable concentration of research activity in: micropulsations of the earth’s magnetic field and the velocity, polarization, and direction of travel of hydromagnetic waves in the ionosphere.

Meteor Studies

Work continues on the occurrence and duration of individual meteor echoes recorded at relatively low search frequencies.

Relativity

Research into relativistic transformation theory is being conducted in the fields of electromagnetism and quantum mechanics.

UNIVERSITY OF NEWENGLAND

Department of Physics

Research and post-graduate training in physics is concentrated in the fields of solid-state and chemical physics, discharge and plasma physics, and ionospheric physics, with small individual projects in musical acoustics and in thermoelectricity.
Solid-State and Chemical Physics

Work concentrates on the properties of disordered and amorphous solids (ice, ionic crystals of AgI or CaF₂ structure, intermetallic materials like AuGa₃, and amorphous semiconductors like SbSe₃) and uses a wide variety of experimental and theoretical techniques for their study.

Gas Discharges and Plasma Physics

This group is concerned with atomic collisions and pre-breakdown phenomena, particularly in magnetic fields, with highly time-resolved studies of the glow-to-arc transition and with gas-discharge laser physics and tunable dye lasers.

Ionospheric and Radiophysics

Studies involve non-linear wave interaction processes in the lower ionosphere, ionospheric electron-density studies using geostationary satellites, studies of fading processes, and the development of a novel high-power pulse transmitter.

Theoretical work is concentrated in the solid-state area and is concerned largely with quantum theory of metals, with field gradients in ionic crystals, and with studies related to disordered solids.

The Department has a particularly well-equipped workshop and students have access to the University's ICL 1904A computer. Most of the research projects are supported by outside funds and have well developed special equipment.

Each of the major groups could accept up to three additional students in 1972, financial support being available mostly in the form of Commonwealth Postgraduate Awards, though there are occasional vacancies for Teaching Fellowships. The Department is also prepared to accept a limited number of students at Physics IV (honours) level. Inquiries on the opportunities for post graduate study are welcomed and should be addressed to the Head of the Department.

THE UNIVERSITY OF NEW SOUTH WALES

Department of Applied Physics

Physics of Materials

Materials used in technology, including polymers, timber, metals, etc., with emphasis on mechanical properties. One field of study is the creep of paper and similar materials. The Department possesses a small high-grade universal tensile-testing machine and other facilities for mechanical testing and heat-treatment of materials, also for microscopical examinations (including access to a scanning electron microscope). Development of high-speed mechanical testing in 1972 is envisaged.

Physical Processes of Thermal and Anodic Oxidation

Equipment includes a constant-current source and an electronic microbalance, with which controlled oxidation of metal specimens may be carried out. The facilities mentioned above for microscopical examination are also especially valuable here.

Physics Applied to Road Safety

A novel type of vehicle-borne radar is under development. One long-term possible use of this is in an automatic vehicle piloting system. Computer simulation of the performance of such a system, aimed at developing a suitable algorithm for the system, is in progress. A novel universal tire-testing trailer has been devised and constructed and is ready for research on friction between tire and road when both steering, and braking to low rotation speed, are applied to the wheel. A novel night-driving simulator has been designed and constructed and is ready for use to study driver-somnolence and somnolence-warning devices. Equipment available includes two motor vehicles and a well-equipped garage-laboratory.

The Department could house and supervise up to 6 postgraduate students to commence in 1972. Commonwealth and University Open Postgraduate Awards are tenable in this Department as elsewhere. A Scholarship specifically for tire-road friction studies, funded by the Olympic Tyre and Rubber Co. Pty Ltd, is available with the same stipend, etc., for 2 years, with possible extension.

School of Physics

Solid-State Physics

Most of the research in this School lies in the field of solid-state physics. Electrical and thermal transport effects are being studied on a variety of materials including dielectrics, semiconductors and superconductors, from the temperature of liquid helium up to 2200°C. The bombardment of solids with ions is being studied with particular attention to channelling effects. Fracture of solids is being examined using optical, X-ray, and electron microscope techniques. Other work on magnetism and on acoustic attenuation by defects in solids is also in progress. In much of this work there is active collaboration between the School and AAECRE at Lucas Heights. Similarly the crystallography group is combining X-ray studies at the University with neutron diffraction work at Lucas Heights.

The surfaces of solids are being examined intensively using a variety of techniques including low- and high-energy electron diffraction and electron paramagnetic resonance. A recently acquired scanning electron microscope is supporting this and other work of the School.

Biophysics

A variety of problems is under investigation. These range from experiments on the electrical characteristics of cell membranes to investigations of feedback mechanisms in man. Water molecules absorbed by biological systems are being studied by nuclear magnetic resonance. Contact is maintained with the physicists at the teaching hospitals of the University.

Atomic Physics

Precision measurements are being made of atomic excitation cross-sections of astrophysical interest. Work is also carried out on the production and detection of ultraviolet radiation.
Theoretical Physics

This has, until now, received comparatively little attention, but it is expected that the theoretical studies in the school will expand rapidly after the appointment in the immediate future of a new professor. Almost certainly this expansion will take place primarily in theoretical solid-state physics.

Commonwealth and University scholarships are available for well-qualified students. There are also a limited number of teaching fellowships which allow ample time for research for a higher degree. Prospective postgraduate students are invited to get in touch with the Head of School, Professor E. P. George.

School of Textile Technology

The Textile Physics section is concerned with research and teaching in the two broad fields of:

- the physical properties of fibres and the relationship of these properties to the molecular structure of these materials, and
- the physical properties of fibre assemblies such as yarns, cloth, felts and composites.

Funds from the wool industry are available and a large proportion of research involving nine postgraduate students is concerned directly with various aspects of the properties of wool fibres and assemblies of these fibres.

Three postgraduate students (PhD) are pursuing problems related to the molecular interactions and segmental mobilities within the structure of keratin (wool). Their measurements involve the application of electron-spin resonance, X-ray diffraction, variable-frequency mechanical testing, and the diffusion of different solvents using radio-active tracers. Facilities for these measurements are available within the School. Two other postgraduate students are examining the properties of carbon fibres manufactured under different conditions. Their aim is to assess the structural conditions within these fibres leading to fracture. External funds are available for this work and a high-temperature furnace capable of attaining a temperature of 2800°C has been purchased.

In this latter project considerable use is made of the Scanning Electron Microscope installed in the School. This work has also included the application of electron diffraction and the Transmission Electron Microscope to carbon-fibre sections and both facilities are available within the University. There is a large School workshop and a separate Electronics workshop.

Besides postgraduate scholarships from Commonwealth funds, a number of special Wool Board scholarships are available for postgraduate studies leading up to a PhD.

School of Applied Geology

Formal postgraduate training is offered in this School within the Graduate Diploma in Applied Geophysics. The aim of this course is to train suitable graduates in Applied Science, Science and Engineering, who wish to become applied or exploration geophysicists. The Graduate Diploma in Applied Geophysics (Grad.

Dip.) is awarded on the successful completion of one year of full-time study.

The Geophysics Section within the School of Applied Geology carries out extensive research programmes in both marine and on-shore geophysical research. Present enrolments include five full-time PhD, one part-time PhD and a number of MSc students within our research programme. Marine geophysical research is conducted from ships of the Royal Australian Navy and within international scientific co-operation programmes. Postgraduate students working within these programmes are frequently required to spend periods of up to one year at international research institutes, such as the Lamont-Doherty Geological Observatory, during their studies.

On-shore, geophysical research includes development of new electromagnetic systems for mineral exploration and the application of seismic and electrical methods in groundwater exploration. Instrument development includes research into improved performance of the proton magnetometer in marine and airborne applications, electromagnetic instrumentation, and improved seismic telemeasuring sonobuoys for marine wide-angle reflection/refraction studies.

In addition to Commonwealth scholarships, a number of company scholarships have been offered for postgraduate students in the above fields.

School of Electrical Engineering

Department of Solid-State Electronics

The research programme ranges from relatively fundamental studies in the physics of semiconductors and phosphors, through device development, and the development of new techniques for integrated circuit fabrication, to investigations of device-failure mechanisms and reliability studies.

The School Clean-Room Facility is now operational. It is planned that integrated circuits will be fabricated in this Facility, on an experimental basis, toward the end of 1972.

In the device area, a new form of Hall element, discovered in the Department, has formed the basis of design of an IC gaussmeter, designed to operate at frequencies up to 30 MHz. These circuits will shortly be fabricated for the School by AWA Microelectronics, as also will be a magnetically sensitive SCR (silicon controlled rectifier) integrated circuit.

Physical studies of phosphor materials have given rise to the development of high-speed thermographic phosphors an order of magnitude faster than any known to date. Parallel studies are under way which use these phosphors in transient thermal analysis of solid-state devices, and of device-failure mechanisms.

Work has commenced on the application of surface elastic waves to the development of a number of new electronic devices, including crystal-controlled oscillators, magnetometers, and signal-processing devices. Initial studies have also commenced of an ultrasonic holography system, and on the modelling of neural networks in the general area of bionics.

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Postgraduate studies may be undertaken which lead to the degree of Master of Engineering Science, MSc, ME or PhD. Honours BSc graduates who have specialized in Physics commonly enrol for MSc or PhD degrees.

The School offers graduate subjects, which may be taken individually or as part of a graduate course leading to the degree of Master of Engineering Science. A selection of these subjects may also be prescribed as a part of the requirements for candidates proceeding to other higher degrees.

Commonwealth Postgraduate Research Awards and Commonwealth Course Awards are available on a competitive basis within the School of Electrical Engineering. There is also a limited number of positions available as teaching fellows within the School. It is anticipated that there will be opportunities for 2 or 3 research students to commence work in the Department in 1972.

More detailed information is given in the School's Graduate Studies Handbook which is available on application to Professor L. W. Davies, Head, Department of Solid-State Electronics, School of Electrical Engineering, The University of New South Wales, Kensington, NSW 2033.

W. S. and L. B. Robinson University College, Broken Hill

The two members of the academic staff of the Physics Department are engaged in research in fields outlined below.

Underground Heat Flow

Heat and moisture pick-up by ventilating air as it passes through mine openings is being studied. The main subject of investigation has been through ventilation in horizontal driveways and vertical shafts, but work has also started on duct ventilation.

Continuous temperature-measuring equipment using thermistors, psychrometers, and airflow and virgin rock temperature-measuring equipment is available.

Cloud Physics

Investigations are being carried out into the ice-nucleating properties of foreign particles, which occur as aerosols in the atmosphere of a semi-arid environment.

The University College at Broken Hill has up to four research scholarships available to approved applicants, and any person holding qualifications meriting consideration for the award of a scholarship should forward full details of their qualifications and field of interest to The Director, Broken Hill Division, University of NSW, PO Box 334, Broken Hill, NSW 2880.

Wollongong University College

The Physics Department has limited research facilities in the areas of astronomy (18-inch reflector) and Mössbauer spectroscopy. Facilities for the testing of near-infra-red and visible-radiation detectors are being developed. There is also the possibility of research in co-operation with the AEC research establishment at Lucas Heights. Scholarships available are those normally awarded within the University of New South Wales.

UNIVERSITY OF SYDNEY
School of Physics

Daily Telegraph Theoretical Department, Prof. S. T. Butler

Opportunities exist for research in Theoretical Physics in the following range of subjects.

Investigations into the propagation of magneto-hydrodynamical waves in plasmas.

Theoretical study of methods for producing highly excited neutral atoms for injection into plasma devices.

Plasma kinetic theory.

Direct nuclear reactions. The study of direct nuclear reactions provides one of the most powerful tools for determining properties of nuclei and of nuclear energy levels.

The many-body nuclear problem. This problem is of great importance in giving a guide as to whether a nucleus can adequately be described in terms of the 'two-body' force or whether 'many-body' forces arise.

The three-body problem. The problem of calculating the properties of $^3$H and $^3$He from assumed nucleon-nucleon potentials is of considerable interest in nuclear physics.

Falkiner Nuclear Department, Prof. C. B. A. McCusker

The Nuclear Department is interested in very-high-energy nuclear interactions and in the astrophysical aspects of cosmic radiation.

Two main experiments are in progress. The first is on the University campus and consists of Wilson cloud chambers, 64 plastic scintillators, and about 200 GM counters and is used to study the cores of air showers of primary energy around 1 000 000 GeV. A number of high-pressure cloud chambers and various other devices are being added to this to study lightly ionized tracks in air shower cores and other features of very-high-energy nuclear interactions.

The other array is the world's largest cosmic-ray detector. At present, it covers 40 square kilometres and is being extended to 100 square kilometres. It is situated in the Pilliga State Forest, near Narrabri, NSW. It studies cosmic rays in the range $10^{10}$ eV to greater than $10^{21}$ eV. The manner in which such particles are accelerated and propagate in the Universe is of great astrophysical and cosmological interest.

Wills Plasma Physics Department, Prof. C. N. Watson-Munro

There are five major plasma sources in the laboratory at the present time—these sources can provide hydrogen, heavy hydrogen, helium, nitrogen, and argon plasmas in the density range $10^{12}$–$10^{17}$ cm$^{-3}$, temperature 1–5 eV.

Research in the Wills Department has been largely associated with the interaction between electromagnetic waves and plasma embedded in a magnetic field.

Magnetohydrodynamic Region ($10^8$–$10^9$ Hz)

Studies of magnetohydrodynamic wave propagation and the heating of plasmas.

Studies of separation of isotopes with plasma centrifuges.
Microwave Region (10^9–10^11 Hz)
Studies of the left-hand circularly polarized and right-hand circularly polarized waves propagating parallel to a steady magnetic field.
Studies of the ordinary and extraordinary electromagnetic waves propagating perpendicular to a steady magnetic field.
Microwave studies of electron cyclotron harmonic radiation.

Infrared Region (10^13–10^14 Hz)
The School of Physics has constructed a new far-infrared laboratory.
Cyano-nitric oxide as an intense source of far-infrared radiation.
A far-infrared detector of the indium-antimonide free-carrier photoductive type complete with a superconducting magnet.
An infrared helium-neon laser for measuring plasma density.

Visible Region (10^15 Hz)
Image Converter Camera capable of fractional microsecond exposures for photographic studies.
Ruby laser (200 MW) for measurement of electron density and temperature by scattering of light by electrons in a plasma.
Studies of spectral lines with a monochromator of high resolution to yield information on electron density and temperature.
Helium-neon laser to measure electron density.

Chatterton Astronomy Department, Prof. R. Hanbury Brown

Optical Astronomy. The principal research programme of this department is concerned with the measurement of the apparent angular diameters of the bright visible stars using the Stellar Intensity Interferometer. The main result of this work, has been to establish a temperature scale for very hot stars. The work has been extended to the study of double stars. The observations are carried out at Narrabri Observatory, which is run by the department. The Stellar Interferometer consists of two large optical mirrors (22 feet in diameter) mounted on a circular railway track 618 feet in diameter.

As the first stage of this work has now been completed no new research students can be accepted pending a decision on a larger instrument.

A second programme of the department is concerned with making optical observations with conventional telescopes. This work is carried out with telescopes at Mount Stromlo and Siding Spring Observatories, which are made available through the courtesy of the Director.

Astrophysics Department, Prof. B. Y. Mills

Radio Astronomy. This department operates the Mills Cross radiotelescope at the Molonglo Radio Observatory and is concerned principally with observations made with this instrument.

The radiotelescope has arms approximately 1 mile in overall length, is very convenient to use, and may be quickly set to scan any declination south of +19°.

It is used partially as a survey instrument, eventually to explore the whole southern sky, and partially to observe the radio emission from selected objects of physical interest, such as external galaxies, supernova remnants, HII regions and members of the solar system. A substantial programme is also directed towards finding and measuring the properties of pulsars.

The last two Departments also share the facilities of the Cornell–Sydney University Astronomy Centre.

Postgraduate enrolment in the School of Physics has always been restricted on quality and will so continue. Annual intake is usually about 10. Research students in the School of Physics are at present supported on such scholarships as Commonwealth Postgraduate Research Studentships, Sydney University Research Studentships, available to countries other than Australia as well as Australians, CSIRO Postgraduate Studentships, and General Motors–Holden Postgraduate Studentships. Almost all of the postgraduate students in the School of Physics have secured financial help from one of the above awards. Teaching Fellowships are also available but will not be given to students of a lower standard than those normally awarded a Commonwealth Postgraduate Research Studentship.

UNIVERSITY OF WESTERN AUSTRALIA

Department of Physics

Theoretical Physics

Statistical mechanics of cooperative transitions; plasma physics—particularly wave phenomena in plasmas—and some aspects of general relativity.

Solid-State and Chemical Physics

The Department has its own Collins helium liquefier and carries out research in the following areas.

Structure analysis—the accurate analysis of molecular structures using X-ray and neutron-diffraction methods.

This group has two automatic diffractometers.

Cooperative phenomena—the precision high-resolution measurement of the thermodynamic functions in the neighbourhood of the gas-liquid critical point.

Microstructures—the nucleation and growth phenomena which occur during the formation of thin metal films by deposition from the vapour onto crystalline substrates. This group uses the facilities of the University Electron Microscopy Centre.

Molecular excitation and dissociation in collisions of gas atoms in the range 0.1 to 2 keV.

Soft X-ray spectroscopy (50–1000 angstroms) of pure metals and alloys.

Electronic transport phenomena in metals—the thermal and electrical conductivities and thermoelectric powers of pure noble metals and their alloys.

Biophysics

The study of the motion of the basilar membrane in the inner ear using the Mössbauer effect to determine velocity.

The investigation of the binding of iron atoms in the molecule transferrin.
Geophysics

Growth and structure of ice formed in supercooled clouds—particularly the basic processes involved in the growth of hailstones. This group has a cold room and wind tunnel.

Mass Spectrometry—to determine stable-isotope abundances particularly of the rare gases in terrestrial rocks and meteorites.

Nuclear Physics

Photonuclear reactions—investigated with the bremsstrahlung from a 33-MeV electron synchrotron.

Astronomy

Photonuclear studies of southern galactic clusters and of variable stars in southern globular clusters. The Department has a 40-cm reflector in operation at the Perth Observatory, Bickley.

There are no postgraduate courses required to be taken by students enrolled for a higher degree. Students are able to attend the optional courses given for Honours students. Commonwealth Postgraduate Awards can be taken up and students from interstate or overseas can apply for the University studentship, but preference is given to local students.

AUSTRALIAN INSTITUTE OF NUCLEAR SCIENCE AND ENGINEERING

The Institute provides financial support for research and training projects in nuclear science and engineering, and arranges access to the specialized facilities at Lucas Heights required for such projects. The support offered includes AINSE Post Graduate Research Studentships for which candidates must be nominated before November 15 each year by the university concerned. These awards are normally tenable for three years (leading to PhD), and the student’s project must require the use of Lucas Heights facilities to the extent that the student spends at least one quarter of his time at Lucas Heights.

The Institute also offers AINSE Research Fellowships which are postdoctoral awards tenable at Lucas Heights, or at an Australian university. A candidate must be nominated by either the AAEC (for awards tenable at Lucas Heights), or by the university in Australia at which he wishes to hold tenure.

Among the fields of physics for which AINSE grants and awards may be offered are: atomic, nuclear, and neutron physics (specified by projects involving the use of reactors or accelerators at Lucas Heights), and solid-state physics (particularly projects involving neutron-diffraction techniques, and projects relevant to nuclear instrumentation). Other areas of physics which require the use of Lucas Heights’ facilities or are relevant to the nuclear fields may also be supported.

Further information is available from AINSE, Private Mail Bag, PO, Sutherland, NSW 2232.

LETTERS

PhD Intake

Sir:—The alarming lack of suitable employment for Physics PhD’s in Australia is a source of ever increasing concern.

Has the American Arden House proposal (Nature, 1971, 229: 448) been considered at all as a solution to the Australian crisis? This proposal involves a curtailment by each Physics Department of the annual intake of PhD students. Money previously used to support and train these students, would be directed to postdoctoral fellows. Not until nearly all of the postdoctoral fellows in a department have found suitable employment would more PhD candidates be accepted.

Such a servo-system would automatically gear the supply of PhD’s to the demand. Perhaps other readers interested in the employment crisis would care to comment for or against the above proposal.

Physics Department,
James Cook University,
Townsville,
Queensland.

G. A. BIELIG
D. T. PEGG

AIP Symbol

Sir:—I feel compelled to voice my opposition to the adoption of the symbol for the AIP described on page 123 of the August 1971 Australian Physicist. The interpretation of the symbol given in the fourth paragraph is a most worthy one, but since the symbol will never be accompanied by this explanation I believe it is more likely to be interpreted to mean that the AIP does not know which way it should be going.

Physicist-in-Charge,
Cancer Institute,
Melbourne,
Victoria.

K. H. CLARKE
MODELS AND METHODS IN THE STUDY OF BLOOD FLOW THROUGH THE LUNG

J. E. Maloney
Department of Physiology, University of Melbourne, Parkville, Victoria

Introduction

It is customary to divide the circulation of blood through the body into two main parts—the pulmonary circulation or circulation of blood through the lungs and the systemic circulation or circulation of blood through the rest of the body. Compared with other organs in the body the lungs provide a vascular network of low resistance and carry almost all of the output of the heart.

A schematic lay out of the circulation is shown in figure 1. Here it can be seen that the heart is divided into two pumps, left and right, and that the lung is placed between these pumps. Blood leaving the lung and destined to be pumped by the left heart around the body is rich in oxygen at a partial pressure of 100 mm Hg. and a content of 20 vols %. Blood returning to the lung in the veins has been depleted of oxygen and has a partial pressure of oxygen of 40 mm Hg and content of 15.5 vols %.

To bring about this exchange of gases in the lung the blood vessels divide from a vessel (the pulmonary artery) approximately 2 cm in diameter to millions of small capillaries about 8 μm in diameter. Similarly the airways of the lung divide into branches of smaller diameter until they finally end in the gas exchanging sacs of the lung (alveoli) which are about 200 μm in diameter. The capillaries run in the walls of the alveoli in a dense network (figure 2) and gases move under diffusion gradients either into or out of the blood across the alveolar-capillary membrane which is approximately 0.2 μm in thickness.

There are three basic elastic components of the walls of the blood vessels in the lung and their proportions in the wall change from the pulmonary artery to the capillaries and pulmonary veins. These elastic elements are collagen, a fibrous protein with a Young's Modulus (YM) of $10^8$ Kg wt/cm$^2$; elastin, another protein (YM = 3 Kg wt/cm$^2$) and smooth muscle (YM = 1 Kg wt/cm$^2$). The characteristics of this last element can be altered by chemical, hormonal or nervous influences. Not only does the architecture and structure of the blood vessels make a physical consideration of the pulmonary circulation complicated but so does the rheological properties of blood.

Models of the Pulmonary Circulation

There have been three approaches to the modelling of the pulmonary circulation which depend on data from three types of experiments.

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**Figure 1**
A schematic diagram of the circulation of blood through the body. Blood is pumped from the right heart through the pulmonary artery and the lung to the left heart. From here it is pumped through the aorta into the rest of the body.

**Figure 2**
A photograph of a capillary network of the frog lung. The human lung shows a similar arrangement of the capillary segments which are smaller in size. Blood flows from a small arteriole at the top through the capillary network to the draining venules at the bottom.
In the first approach, the data comes from measurements of pulsatile blood pressure and blood flow which may be made in the pulmonary artery of man [Mills et al., 1970], experimental animals [Bergel and Milnor, 1965], or in an isolated lung preparation [Maloney et al., 1968]. Typical pressure and flow wave forms are shown in figure 3. Since the wave forms are not identical any analogue of the system must involve a consideration of inertial, capacitative and resistive components. One of the earlier proposals for such a system was that of a simple elastic tube terminated by a high resistance [Taylor, 1957] in which the modulus of impedance would change with frequency. In this system impedance would fall from a high value to a minimum at a frequency at which the elastic tube was one-quarter of a wave length long. Using this model a major reflecting site in the pulmonary circulation was estimated to be 18 cm into the lung in man [Mills et al., 1970], or 17 cm in the dog [Bergel and Milnor, 1965]. Because the simple model of the vasculature did not explain all the observed variations in the impedance with frequency, particularly in the systemic circulation, a new model was proposed [Wiener et al., 1966] which consisted of a randomly distributed series of elastic tubes and led to improved agreement between experiment and theory. Since the distributed series of elastic vessels was a more realistic model of the circulation, a uniform distributed network [Wiener et al., 1966] was used in 1966 to predict the transmission of pulsatile pressure and flow throughout the circulation of the lung. The harmonic analysis of the pressure and flow pulses showed significant attenuation of both the flow and pressure pulses at the level of the microcirculation in the lung. The predictions from this model were confirmed in part by measurements in the isolated lung and in the pulmonary circulation of the anaesthetised dog [Pinkerson, 1967].

A second and novel approach to modelling in the pulmonary circulation has been undertaken at the alveolar-capillary level. These studies are important because ultimately a knowledge of how the blood behaves in the microcirculation of the lung is necessary in understanding lung function and gas exchange. For some time the capillaries were regarded as short cylindrical tubes but recently the term sheet-flow [Fung and Sobin, 1969] was introduced. Here the blood consisting of red blood cells and plasma flows between two sheets of tissue cells (endothelial cells) which are held apart by tissue posts. Figure 2 provides a plan view of the system. The structure of the model was supported by recent observations of the capillary microcirculation in the cat lung [Sobin, Tremer and Fung, 1970] though the predictions of the model in relation to pressure and flow contours have yet to be confirmed.

A third approach to the modelling of the pulmonary circulation developed from a desire to explain the distribution of blood flow in the lung which was shown to be dependent on the gravity vector. In brief, there is a gradient of blood flow from the apex to the base of the lung. The model consists of a vertical array of vascular elements (figure 4) whose input and output pressures are a function of height above the base of the lung. The elements are interesting in that they contain a collapsible segment at the level of the capillaries of the lung which closes when its internal pressure is below its surrounding

![Figure 3](image)

**Figure 3**
Pulsatile blood pressure and flow curves in the pulmonary artery of the sheep. The flow curve is recorded with a "cuff"-type electromagnetic flowmeter which is placed around the vessel. The pressure is recorded by a manometer with a fluid filled catheter placed in the pulmonary artery. Pressure is given in ccm H2O and flow in arbitrary units.

![Figure 4](image)

**Figure 4**
A model of the lung as a vertical array of vascular units. Pa is pulmonary artery pressure; Pp is pulmonary venous pressure; Pr is the critical closing pressure; Pva is the pressure around the thin walled collapsible vessels in the alveoli and Pa is the blood pressure just downstream of the collapse point.
pressure [Glazier et al., 1969], and provided the pressure \( P_0 > P_{\text{atv}} \), the flow of blood through the unit is governed by \( P_a - P_{\text{atv}} \) and not the more characteristic \( P_a - P_y \). There appears to be little detailed analysis in the literature on the flow of fluid through collapsible tubes. The lung contains elements in two states, where \( P_0 < P_{\text{atv}} \) and where \( P_0 > P_{\text{atv}} \). Flow in the lung in these situations has been analysed by Permutt and Riley [1965]. A further proposition is that the vascular element contains a portion of its wall which collapses when the intraluminal pressure falls below a critical level \( P_e \). This may be due to active tension generated in the smooth muscle in the wall of the blood vessel. An early quantitative analysis of the distribution of flow [Fowler, 1965] suggested that either the elastic characteristics of the vascular elements should have a Young's modulus which is implausibly low, or that significant critical closing of blood vessels occurs in the lung. That there is critical closure has been confirmed by a number of authors [Permutt et al., 1966; Maloney et al.]. The analysis of the distribution of blood flow in the lung was extended in a comprehensive analogue model of the pulmonary circulation [Gray, 1968] in which the importance of the critical closing pressure was again stressed and in which it was suggested that the anomalous fall of blood flow in the vascular units towards the base of the lung was most readily explained if there is a systematic increase in critical closing pressure in that region which is related to the distance down the lung.

A major problem in the construction of models of the lung is the paucity of biological data upon which to erect the model. The difficulty is often one of technique in that the methods are not available to explore in detail the characteristics of the system to be analysed. In this sphere many methods remain to be developed to assist in the understanding of the physiology of the animal whether in an isolated organ system, an anaesthetised preparation, or in the intact unanaesthetised animal and man.

Measurement in the pulmonary circulation

There are four types of experiments in physiology which aim to analyse the function of an organ system. The first type is the measurement of physiological parameters in isolated groups of cells or strips of tissue; the second is the measurement of the function of isolated organ systems; the third is the measurement of function in organ systems where the animal is anaesthetised and finally, the fourth is measurement in the unanaesthetised animal. The ability to control the variables of the system decreases at each level and thus the analysis of the results becomes more complicated. Here the discussion shall be confined to some of the measurement techniques which are used in the last three situations.

Blood Pressure

The techniques [Rushmer, 1970] for the continuous measurement of blood pressure are well established. In the first a pressure pulse is transmitted out of the vascular system through a fluid filled tube to an electro-

manometer. In the manometer the pulse is detected by a continuous change in position of a diaphragm which is converted into a change of resistance, capacitance or inductance. Faithful reproduction of the pressure wave is related to the frequency characteristics of the system which depend in part on the size and material of the catheter and manometer and their complete filling with the fluid. More recently small solid-state pressure transducers have become available which are based on the piezo-resistive effect of silicon or germanium. Their small size has been made possible by the use of integrated circuit techniques.

Measurements of pressure in the microcirculation of the lung are more difficult because of accessibility, the small size of the blood vessels which are usually less than 500 \( \mu \)m and movement. However, a micro-pressure transducer was developed by Wiederhold [1966] in which a small glass microelectrode of tip diameter 0.5 \( \mu \)m or less is inserted into the lumen of the vessel. The microelectrode, filled with 1M saline, alters its impedance as the saline-plasma interface moves further into the tip. The impedance change is detected and a servo system drives the interface to its balance position. The pressure inside the servo system is monitored continuously and reflects the pressure in the blood vessel. Marked pressure attenuation has been measured in the frog lung [Maloney and Castle, 1970] and the rabbit lung [Rappaport et al., 1959] in vessels down to 80 \( \mu \)m in diameter.

Blood Flow

Continuous measurement of pulsatile blood flow has been possible since 1936 when Kolirn [1936] in the United States and Wetterer [1937] in Germany introduced the electromagnetic flow meter. The transducer in this unit is based on Faraday's law of induction where a voltage is induced in a conductor which moves through a magnetic field. Blood being an ionic solution is a conductor, and if it flows through a magnetic field a potential difference can be recorded between electrodes with which it makes electrical contact. Flow probes of this type may be placed around a vessel in close contact with it or may be built into the end of a catheter which can slid into the pulmonary artery via a peripheral vein.

A second method of measuring blood flow depends on the fact that the velocity of sound in a fluid is related to the velocity of that fluid. The transit time of a burst of ultrasound is measured between two crystals mounted diagonally across a blood vessel. A comparison is made of the transit times in each direction from which the velocity of blood flow may be computed. There is a further technique using ultrasound in which flow velocity is indicated from the Doppler shift of the ultrasound as it travels between a transmitter and receiver crystal.

Recently a technique for measuring the velocity profile across major arteries has been developed. After exposure of the vessel, a small thin film anemometer is introduced through the wall of the vessel and measurements of the velocity of flow plotted across the diameter.

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of the vessel. The linear flow velocity is relatively constant across the vessel which may result from the presence of the oscillating components of the flow pulse as suggested by Hale, McDonald and Womersley [1955]. In this device the fluid velocity is related to the rate of transfer of heat from the thin metal film. The transfer of heat cools the film and alters its resistance to initiate the output signal from the device.

Finally, in the measurement of the distribution of blood flow in the lung, two radioisotope techniques have been developed. In the first, small macroaggregates of isotope such as Iodine-131, or Technetium-99m (approximately 50 μm in diameter) are injected into a peripheral vein from where they pass through the chamber of the right heart and into the lung to be trapped in the small blood vessels. The proportion of isotope trapped at each level of the lung is a direct measure of the fraction of the blood flow through the pulmonary artery arriving at that level. An alternative approach is to inject a solution of radioactive xenon-133 into a peripheral vein. When the xenon-133 reaches the alveolar-capillary membrane it diffuses out of the blood into the alveoli. The distribution of the isotope in the lung is measured by conventional gamma ray counting techniques. Because these isotope techniques are simple they have been used extensively in the study of factors controlling the distribution of blood flow in the lung of man, experimental animals, and isolated lung preparations. In man, alterations of lung function in disease have been studied with these radioactive isotope techniques.

**Conclusion**

The above outline presents some of the approaches which are used in the study of the circulation of blood through the lung. The discussion was limited to two models of the circulation and a general statement of methods that are used to measure blood pressure and flow in the lung. No significant mention has been made of factors which control the pulmonary circulation nor has there been a detailed discussion of the rheology of blood flow in the lung. Research into both these areas is growing with a move towards the measurement of basic data in anaesthetised animals and man. Problems still exist in the study of the rheology of flow in the microcirculation of the lung and much of the basic data required for a detailed analysis is not yet available.

**References**


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**NOTES AND NEWS**

**Electro-optics, Quantum Electronics Conferences**

An International Conference and Exhibition on Electro-optics System Design will be held in Brighton, England, 29 Feb.–2 March 1972. Secretary is Dr L. R. Baker, Head, Optics Systems Division, Sir A. Institute, Chislehurst, Kent, BR7 5EH, England.

The Seventh International Quantum Electronics Conference will be held in Montreal, Canada, 8-11 May 1972. The Technical Program Secretary is Professor B. P. Stoicheff, Department of Physics, University of Toronto, Toronto 5, Ontario, Canada.

**Fourth Australasian Conference on Hydraulics and Fluid Mechanics**

This conference will be held at Monash University, 29 November to 3 December 1971. Some 90 papers, on a wide range of topics, are to be presented. The fee for the Conference is $37, which includes the cost of the Proceedings. A Conference Handbook, which gives programme details, and enrolment forms are now available from the Secretary, 1971 Fluids Conference, Department of Mechanical Engineering, Monash University, Clayton, Vic., 3168.
The Physicist in the Kitchen

On Wednesday, 11 August the Victorian Branch sponsored the public lecture of Professor Nicholas Kurti, called 'The Physicist in the Kitchen' at Monash University. This was attended by 450 people, who completely filled one public lecture theatre and overflowed into a neighbouring theatre equipped with closed circuit television. The ABC videotaped the lecture for a possible future broadcast. The lecture was similar to one given two years ago by Professor Kurti at the Royal Institution, London.

There were several themes running through the lecture. Firstly there was a plea for physicists to concern themselves with applied problems. Secondly there were mentioned the specific advantages to physicists looking at problems of cooking, and Brillat-Savarin's maxim was mentioned—'The discovery of a new dish contributes more to human happiness than the discovery of a new star.' Among the techniques mentioned and demonstrated by Professor Kurti were the hypodermic syringe (for insertions in situ into foods, especially rum into mince pies), thermocouples for temperature recording inside foods as they cooked, and the use of a vacuum for making meringues. The meringues were made under a bell jar connected to a vacuum pump and they were much lighter than conventional meringues. A good supply was available at the end of the lecture.

In traditional cooking, heat is always applied on the outside and one relies entirely on the conduction of heat for the inside of the material to get cooked. There are in fact temperature gradients within the dish and the subtle variations of texture, taste, and colour in roasted, baked, grilled, or fried food are the manifestations of this temperature gradient. The dish which has these qualities to extreme is the Soufflé Surprise (Baked Alaska) in which the ice cream is covered with a meringue mixture which is then cooked in a very hot oven. The development of microwave cookers makes it possible to reverse this temperature gradient. Microwaves lose some of their energy in the material, the amount depending on the chemical composition and physical state. Microwave cookers are invaluable for the quick warming up of precooked food (frankfurters were available at the lecture). The temperature gradient can be inverted in a microwave cooker so that the ice cream on the outside remains cold while the filling becomes hot. This too was demonstrated. After the lecture, many of the appreciative audience remained to sample the foods prepared by Professor Kurti. One speciality was deep frozen lollipops fried in batter.

Such a lecture demanded much preparation and assistance; the physics department at Monash had collaborated in many ways to produce the equipment. The microwave cooker was lent by Philips. Professor Kurti was assisted throughout the lecture by two assistants, Miss Jennie Lloyd, a physics undergraduate of Monash and Miss Leanne Grigg, a physics student from Presbyterian Ladies College, Melbourne. The evening was scientific entertainment in the direct tradition of a Friday Evening Discourse at the Royal Institution.

Going Metric

The Australian Physicist will adopt SI units as from the January issue, 1972, and authors are asked to use only SI units in their manuscripts. Further details will be given in future issues.

Laser Interferometry at Sydney Machine Tool Exhibition

Hewlett-Packard Aust. Pty Ltd. will display their model 5525B Laser Interferometer at the forthcoming Machine Tool Exhibition to be held in Sydney, 14–23 October. The Laser Interferometer will be mounted on a Herbert/De Vlieg Jigmill model 43H72 boring and milling machine to indicate the travel of the 'X' axis.

Rheology Conference

The Sixth International Conference on Rheology will be held in Lyon, France, 4–8 September 1972. The Organizing Secretary is Dr C. Smadja, Boîte Postale No 1, 69-Lyon-Mouche, France.
WA Branch Notes

Attendances at recent WA Branch meetings have been excellent. Between 50 and 100 members and guests have attended each of the 1971 meetings.

Visit to the Medical Physics Department, Royal Perth Hospital

The March meeting took the form of an inspection and demonstration of the large-field scintillation camera recently installed at the hospital. Mr R. W. Stanford, the Head of Department, welcomed members prior to giving an absorbing address on present and projected usage of the camera for rapid organ imaging and for various dynamic studies. An impressive demonstration of the camera at work was performed by Mr R. Fleethy. It was most evident from the success of this particular meeting that members appreciate a change in the usual meeting format.

Professor Takatoshi Murata

At the April meeting, Professor Takatoshi Murata from the Kyoto University of Education gave a talk entitled ‘Teacher Training and Research in Physics at Japanese Universities’. Professor Murata outlined course structures in Japanese universities which give particular emphasis to the training of science teachers. The lively discussion that followed the lecture was indicative of the tremendous interest in the material presented.

Dr John Black

Dr John Black, formerly of ANU, who took up a position in the Department of Nuclear Medicine at the Sir Charles Gairdner Hospital earlier this year, addressed the May meeting on the topic ‘The Role of a Physicist in a Modern Hospital’. The talk was aimed primarily at student physicists who are considering medical physics as a vocation. Dr Black gave a lucid account of the duties of physicists in general hospitals, with particular emphasis on nuclear medicine, computer, heart and pressure monitoring, and surgical equipment.

Dr Brian O’Brien

The address by Dr Brian O’Brien, recently appointed as Director of Environmental Protection in Western Australia, attracted an audience in excess of 100. The title of the address was ‘The Role of Physicists in Environmental Protection’. Dr O’Brien presented a broad view of the central issues of environmental protection. He emphasized the difficulty of finding acceptable solutions to problems concerning the environment, and urged that systems analysis be applied to these problems.

Dr O’Brien called for all scientists to concern themselves with environmental protection. Effective solutions could only be found through interdisciplinary research. There was an urgent need for more intense research into environmental protection requirements so that any future legislation could be effectively implemented.

In calling for a rational approach to the problems of environmental protection, Dr O’Brien deplored the excessive use of terms such as pollution, ecology, and environment. He expressed some concern that these terms were becoming rather meaningless clichés through popular use.

The Seventh Pawsey Memorial Lecture

The high point of the year was the 1971 Pawsey Memorial Lecture delivered by Dr E. G. Bowen, CBE, FAA, who recently retired as Chief of the Division of Radiophysics, CSIRO. The lecture was held in Hayman Hall, WAIT, on 29 July before some 400 guests.

Dr Bowen’s stimulating lecture was entitled ‘From Radar to Radiophysics’. He described the development of Radar from fundamental work on radio-wave propagation; and then went on to describe the subsequent development of radio astronomy. The importance of interplay between science and technology was emphasized.

In the second part of his lecture Dr Bowen described three important radio-astronomy observations—the study of solar flares, the discovery of pulsars, and the detection of regions in the Galaxy which appear to contain water vapour.

The full text of Dr Bowen’s address will be published shortly in this Journal.

Careers in Physics

The July meeting of the NSW Branch took the form of a joint meeting with student Physical Societies, and a panel of five speakers presented information on careers in physics. Topics covered were Medical Physics, Secondary Teaching, Physics in Meteorology, Physics in Industry, and Geophysics. Although these are only a sample of the many applications of physics, the talks gave a clear picture of a continuing demand for physics graduates in teaching, but elsewhere a desire to have physicists who also had some knowledge of auxiliary subjects such as: electronics, computer science, mathematics, geography, geology, biology, etc. The formal discussion was lively and this continued unabated at the buffet dinner afterwards. The mixing of students and professional physicists was particularly apparent and presumably was illuminating to both.

Very-Long-Baseline Interferometry

At the August meeting of the NSW Branch, Dr D. S. Robertson (WRE) described the work of the Space Research Group using NASA equipment, when available, for purely scientific purposes. Initially, the two deep space stations at Tidbinbilla near Canberra and at Island Lagoon near Wo Omarra provided a nine million wavelength baseline for interferometry with a resolving power of 10^{-4} seconds of arc. Since the end of 1967 a 90 million wavelength baseline across the Pacific has been in use with the Goldstone 210 foot dish. More recently a trans-Indian Ocean baseline (to Johannesburg) has also been used.

Studies of quasars have indicated expansion velocities much greater than the velocity of light, if the red shift distances are correct. There are explanations of such very high apparent expansion velocities but further work
is needed on this subject and on an apparent preferred orientation of the stronger sources.

Near the Surface of Things

At their July meeting, the SA Branch were addressed by the foundation Professor for the new chair of Meteorology at Flinders University, Prof. P. Schwertfeger. The subject was micrometeorology and its relevance to pollution, environmental change, building engineering, etc.

Professor F. D. Stacey

Dr Frank D. Stacey was appointed to the Chair of Applied Physics at the University of Queensland on 22 April 1971.

Frank Stacey was born in Essex, England, in 1929. He graduated from London University, B.Sc., with honours in Physics in 1950, and was granted a PhD in 1953, and a DSc in 1968. Before coming to Queensland as reader in Physics in 1964, Stacey had held appointments at the University of British Columbia, the Australian National University and the Meteorological Office Research Unit in Cambridge, England.

Of more than 80 scientific publications, the best known is his textbook 'Physics of the Earth' which appeared in October 1969.

Since about 1960 the central theme of Professor Stacey’s research has been the idea that earthquakes are predictable. The search for prediction methods has yielded a patent for a tiltmeter, now being manufactured in New Zealand under licence to the University, and a series of papers on magnetic effects of tectonic activity, which form the basis of the most promising method at the present time.

Scientific and Technical Information Services Enquiry Committee

A Committee has been set up to investigate the adequacy of scientific and technological information services in Australia. Since it believes that any national system must reflect the needs of users and that their views should be obtained, the Committee wishes to make its existence widely known. After surveying user needs, the Committee hopes to bring forward proposals to assist in the formulation of a national policy.

Sponsored by the National Library, the Committee has a membership that represents universities, other institutes of tertiary education, government instrumentalities, industry, and libraries at every level. Two members of the Institute are included; Sir Leonard Huxley FAIP, and Dr P. G. Law FAIP.

Individuals or organizations wishing to submit comments or to obtain further information should contact the Committee Secretariat at the National Library of Australia, Canberra, ACT.

THE REGISTER

Changes in Membership from 16 July 1971 to 13 August 1971

Associateship

(a) New Elections
Bassett, I. M.
Broomhall, G. J.
O’Connell, A. M.
Price, T. C.

(b) Transfers
Coyle, R. A.
Skinner, D. R.

(c) Reinstatement
Bendel, D. (Vic.)
O’Mara, B. J. (Qld)

(d) Deceased
Hirst, G. W. C. (NSW)

Graduateship

(a) New Election
Isopenko, S.
Farrell, K. M.
Pankevicius, E. R.
Rose, M. P.
Russell, A. J.

University of Sydney, NSW
Australian Atomic Energy Commission Research Establishment, NSW
Trace Element Laboratories, WA
Royal Melbourne Institute of Technology, Vic.

(b) Transfer
Chapman, G. J.

(c) Reinstatement
Kont, A. S. (WA)

(d) Removal (Address Unknown)
Fiavellie, A. J.

Students

(a) New Elections
Beck, R. E. (NSW)
Drillis, A. (Qld)
Hughes, J. R. D. (NSW)
Payling, R. (NSW)
Scrib, A. J. (NSW)
Sim, L. H. (Qld)
Williams, I. S. (Vic.)

(b) Removal (Address Unknown)
Clayton, E. J.

(c) Resignation
Banks, D. C. (Vic.)

Subscribers
Resignations
Champion, R. H. S. (SA)
Williams, J. P. (ACT)

Company Subscribers

(a) Removal
The Electrolytic Refining & Smelting Co. of Australia (NSW)—under Clause 13 of the Articles of Association

(b) Resignations
ICI of Australia & New Zealand (Vic.)
The Mount Lycel Mining & Railway Co. Ltd (Tas.)
M & T Products (Vic.)

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BOOK REVIEWS


Reviewed by N. H. Fletcher, University of New England.

Most of the classics on quantum theory, like Messiah and Schiff, are written for graduate students in the US system and there is difficulty in finding just the right treatment for Australian third-year students and perhaps for some of the less rigorous fourth-year courses. The present book may help to fill this gap.

Whilst the author, with his title, tries to steer a middle course between a descriptive book on 'Modern Physics' and a formal treatment of 'Quantum Mechanics', his approach leans towards the latter, and some of the more elementary material seems a little out of place. There is not much of this, however, and the book has a refreshingly contemporary approach to its subject matter. There is a good compact introduction to Hilbert space and to group theory, matrix mechanics and perturbation methods are given a useful treatment, and Dirac notation is used where appropriate. These fundamentals take about half the book. The remainder is about equally divided between a treatment of atomic structure, including the Hartree–Fock equation, spectral transitions, and an introduction to simple diatomic molecules on the one hand and of high energy phenomena, including scattering theory, the Dirac equation and nuclear physics, on the other. The mathematics is given in reasonable detail throughout, including SCF atomic calculations and spin–orbit coupling, and should present no great difficulties at advanced third-year level. The 160 or so problems seem well chosen and thought-provoking and the index is adequate.

The book is not without minor blemishes. The page on Miller indices is not good (and the bracket notation wrong) and several unbelievably poor half-tone reproductions are included (fig. 44 on p. 201 is the worst). All in all, however, it is well worth consideration for advanced undergraduate courses.


Reviewed by J. G. Collins, National Standards Laboratory, Sydney.

This is a revised and greatly enlarged book to replace Tallack's 'Introduction to Elementary Vector Analysis' (Cambridge, 1960). The level is English sixth form/first-year university, and it would be suitable for a first-year pass course in an Australian university. It is a clear, straightforward introduction to vectors.

The book covers definitions and elementary manipulation of vectors, differentiation and integration, scalar and vector products, and triple products; it illustrates the application of vector methods to simple problems of mechanics, solid geometry, twisted curves in space, and electrodynamics.

Tallack writes for the average student taking a mathematics course rather than the potential mathematics major. His explanations of the basic concepts and operations are more expansive than many other texts, yet the style is economical and not wordy. The applications given are conventional: calculation of angles and distances in three-dimensional solids, rotational motion in three dimensions (gyrosopes are briefly mentioned but Coriolis force is not), helical paths of charged particles in magnetic fields, and the like.

Each chapter has a number of type examples worked in detail and a set of exercises with answers.


Reviewed by J. C. Kelly, University of New South Wales.

The uncertainties that bedevil the production of thin solid films have been greatly reduced in the last few years. Cleaner vacuum systems, better control of evaporation and higher-resolution methods of film examination have all helped, but the main driving force has come from the need to make durable, reliable, commercial devices.

As with photography, the technology has in some cases outstripped the physical understanding of exactly why some procedures are consistently successful and some others are not. It would not be true to say that this book provides even most of the physics one requires for understanding thin films but it is a good introduction to the subject. There are seven chapters devoted to Film Preparation, Film Examination, Growth and Structure, Mechanical Properties, Optical Properties, Magnetic Properties, and Electric Properties. The level of treatment is a little uneven and there are a few surprising omissions, for example r.f. sputtering and magnetically focussed electron-beam guns in the preparation chapter and the Scanning Electron Microscope in the Examination chapter. One might also object to the number of figures without captions. This may save a few lines of space but it is irritating when referring back to a figure to have to hunt up the details in the body of the text.

Optical properties of absorbing and multilayer film are dealt with in some detail and this is probably the best section of the book as one would expect from the author's long association with this field.

Technological applications of thin layer films receive some mention in the final chapter on electrical properties.

Overall the book succeeds in its aim of giving a broad introduction to the physics and some of the detailed properties of solid thin films.
Summer School

ADVANCE NOTICE

Australian National University, Canberra

Provisional dates, 24-28 January, 1972

The school will be divided into two sections to run concurrently in the fields of

Astronomy: Recent developments in astronomy

and Geophysics: 1. Geophysical interpretation
2. Crustal tectonics

A number of invited speakers will develop topics in a series of lectures in their various fields of interest.

Registration will be invited at a future date. Accommodation is available at university halls of residence or hotels if required. Further information will be made available in subsequent bulletins or from the secretary of the organising committee:

Mr. D. M. Finlayson,
Bureau of Mineral Resources,
P.O. Box 378,
Canberra City, A.C.T. 2601.

New Books in Physics

THE FUNCTIONS OF MATHEMATICAL PHYSICS
by H. Hochstadt
(A Volume in Pure and Applied Mathematics: A Series of Texts and Monographs)
The functions discussed are those that arise in the solution of certain differential equations used in physical problems. The book is a rare tool for all those working with mathematics and physics.
1971 322 pages $18.40

LASERS, 2nd edition
by B. A. Lengyel
(A Volume in the Wiley Series in Pure and Applied Optics)
This second edition of Lasers is the author's attempt to bring to the reader the vastly expanded field of lasers as they existed at the end of the 1960s. The lucid presentation and carefully chosen references will make this book an asset to the physicist, chemist and astronomer.
1971 386 pages $15.70

SHOCK WAVES IN COLLISIONLESS PLASMAS
by D. A. Tidman and N. A. Krall
(A Volume in the Wiley Series in Plasma Physics)
This is a collection of literature on collision-free shocks in plasma, with the bulk of the book devoted to the basic physics that underlies the subject.
1971 175 pages $11.05

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