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Registered at the G.P.O., Sydney, for transmission by post as a periodical.
Applications are invited for four positions in the Thai-Australia Research Team located at the Chainat Agricultural Centre, Thailand.

1) Crop Agronomist—preferably but not necessarily with experience in rice-growing.

2) Chemist—with an interest in field aspects of nitrogen nutrition and crops.

3) Soils Specialist—soil physics and irrigation, with a special interest in soil/plant/water relations.

4) Extension Agronomist—with experience in irrigation and crops and with an interest in extension training.

Appointments are for two years in the first instance.

The Chainat Agricultural Centre is one of the three existing major agricultural research groups established by the Thai Ministry of Agriculture. The Australian research team has been working at Chainat since 1967-8 on the development of agricultural systems and techniques for growing upland crops in the dry season in combination with the wet season rice crop.

The laboratory is well-equipped for routine analyses—an atomic absorption spectrophotometer and an automatic analyser are currently being used. The associated field station is well-equipped for field research and the research programme is wide-ranging in the general fields of crop agronomy, nitrogen nutrition, soils and irrigation.

The team is assisted by a committee of CSIRO research staff in Australia, funds being administered by the Department of External Affairs.

The Team of four is being expanded to seven and some of the current staff are to be replaced upon completion of their tours.

Applications should be forwarded before 15th June, 1970 to:

Mr L. F. Myers,
CSIRO Division of Plant Industry,
P.O. Box 109,
CANBERRA CITY, A.C.T. 2601.

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ANNOUNCEMENT

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ELECTRONICS FOR SCIENTISTS AT THE ANU

Michael M. Gore
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Introduction

Today electronics has become a basic tool of the vast majority of scientists. It is therefore essential to provide a course at the tertiary level which will enable students to acquire a sound grounding in the subject. It is no longer sufficient for a scientist to be merely capable of dabbling with electronic circuitry. Nowadays, in addition to being able to interpret complex circuit diagrams, the scientist must also be capable of expressing electronic ideas clearly to others as well as displaying some design expertise. The electronics course given in the Physics Department of the Australian National University has been developed over the last seven years in an attempt to satisfy these needs.

Until recently it was difficult, due to the arrangement of courses, for anyone but physical scientists to take electronics as offered in the Physics Department. This difficulty was removed this year when the Science Faculty of the Australian National University changed from the conventional three-term system to a semester system. One of the aims of this change was to give science students a greater degree of flexibility in the subjects they could elect to study by sub-dividing the various disciplines. Under the old system a student majoring in Physics had to take second year physics—Physics II—as a package deal. It was a course of four lectures a week throughout the year and included several other topics as well as electronics. Now, whereas a student majoring in zoology, for example, will have little need for classical electromagnetic theory or quantum mechanics, a knowledge of electronics will frequently prove valuable.

With the advent of the semester system, departmental courses have sub-divided and electronics is now a semester unit in its own right. It is now much easier than it was under the old scheme for the zoology student, who may have no other interest in the physical sciences, to fit electronics into his timetable. It is too early as yet to say if the students will take advantage of the numerous possibilities the new system offers.

One problem which the semester scheme has introduced with respect to the teaching of electronics, is that many of the natural-science students do not have the same mathematical background as, for example, those majoring in Physics. To combat this problem, the first few lectures are devoted to the complex algebra and basic principles of circuit theory, which are used in subsequent lectures.

The Lectures

The electronics course developed in this department includes six hours of experimental work in the laboratory each week, and a programme of thirty-nine lectures. The formal analysis of electronic circuits as presented in the lectures is considered most important. Only in this way can a student achieve a real understanding of how and why a particular circuit functions.

The course covers both semiconductor and thermionic-valve circuits and theory. This approach is used because, although semiconductors will inevitably completely replace valves, there still exists at this time a large amount of equipment in laboratories both in this country and abroad which uses thermionic valves. Much of this equipment is likely to be used for quite a few years to come, and on economic grounds alone cannot be scrapped. It is thus essential that any electronic training should include some mention of thermionic-valve theory and circuits.

The course therefore falls into three main parts, general circuit theory, thermionic-valve circuits, and semiconductor devices and circuits. In nearly all cases a suitable mathematical analysis is given, which is then followed by discussion of the practical considerations of particular circuits. In the section on semi-conductors (given at present by Dr. A. J. Mortlock) a satisfying mathematical or, more often, qualitative explanation is given of the internal functioning of each device before circuit considerations are introduced.

Students will normally take the electronics semester unit in either the second or third year of their degree course. The examination of course material is of the conventional type, the questions demanding both a theoretical and practical knowledge.

The Laboratory

In the laboratory each student has his own bench together with a rack of instruments (figure 1) containing an oscillator, power supply, vacuum-tube voltmeter, and oscilloscope. Rack-mounting equipment was adopted for a number of reasons. Each rack is fitted with wheels, which makes them highly mobile and therefore able to be moved from one laboratory to another quickly and easily. The problem frequently encountered—of teaching apparatus ‘fanding’ its way into research laboratories—does not appear to be worsened by this mobility. This in part is due to the fact that the physical size of the racks allows them to be tracked down more easily.
than individual pieces of equipment. In addition, rack mounting the test equipment not only keeps the bench clear for the chassis under test but also eliminates any chance of a piece of expensive test equipment being accidentally knocked off the bench.

It is essential that the laboratory course produces students who are flexible in their approach to electronic equipment, and that they become accustomed to working with different makes of the same type of apparatus. With this criterion in mind the laboratory was developed without standardizing, for instance, on one particular make of oscilloscope. Thus by the end of the course each student has used three of four different oscilloscopes, oscillators, and power supplies.

In order to reduce the necessity of explaining the features of different instruments week after week, descriptive wall charts have been prepared for each piece of equipment. These charts contain the same information, which is given in the instruction manuals but, by this method of display, it is easily accessible and robust. Students are encouraged to consult these wall charts whenever they encounter a new piece of equipment. Any obscure points can then be dealt with by the laboratory demonstrator.

All the experiments in the course are described in a laboratory manual developed in the department over the last few years. In this manual a brief summary is given of the theory associated with each experiment; this is followed by a brief description of the experimental procedure and finally a number of questions. The student uses these questions as a basis for writing the laboratory report. It must be emphasized that this laboratory manual does not contain step-by-step instructions on how to perform the experiments. It is primarily intended to serve as a bridge between the lecture course and the laboratory. Frequently in science subjects a particular laboratory class will involve a topic which is not dealt with in lectures until much later in the course. The laboratory manual is intended to alleviate this problem.

Although a formal laboratory class is of six hours duration, students are allowed to spend more time in the laboratory if they so wish. The experience has been that the students usually spend longer than the required time, frequently out of choice rather than necessity. After a student has constructed and tested an amplifier of his own design it is not unusual to find that his newly acquired talents encourage him to extend his investigations using his own initiative.

The laboratory experiments include a wide selection of the conventional circuits. There are, however, two particular experiments which vary somewhat from the normal trend and are therefore worthy of being singled out for detailed description.

**Circuit Design**

In the first of these experiments the student obtains design values for all the components in the two-stage R-C-coupled amplifier using either valves or transistors. Specially designed breadboards (figure 2) are provided for this experiment, on which the student can connect up his amplifier for testing. Instead of soldering the components in place, use is made of spring terminals which enable good electrical connections to be achieved. This breadboard is easily dismantled after the student has tested his design and made any necessary alterations. Several breadboards have been constructed, each one utilizing a different combination of valves or transistors.

A library of the necessary valve and transistor characteristics are available in the laboratory and these are somewhat larger than those available from the manufacturers. To prolong their life in the laboratory these characteristics are varnished and glued to sheets of masonite.

**Construction of Apparatus**

The second experiment to be described was introduced into the course because of the frequent complaint from the research laboratories that postgraduate students knew very little or nothing of the practical aspects of assembling circuitry. In many cases students entering research laboratories had never used a soldering iron. In an attempt to rectify this situation a construction experiment was introduced into the course. In this experiment the student is provided with a circuit...
Type C27 to be used. This enables the students to photograph oscilloscope traces obtained when checking these circuits, rather than sketching them. It is also a useful way of introducing students to this method of recording data.

Honours Electronics

A further electronics course is offered to students taking an honours degree in Physics. This course comprises thirteen lectures and covers somewhat more advanced topics than those covered in the earlier course. In addition problems and techniques frequently encountered in the research laboratory are discussed. At the present time there is no associated laboratory course, but each student is required to submit a written project on which he is examined. This project usually takes the form of a review paper on some aspect of electronics—quite frequently some recent development.

Conclusion and Acknowledgements

With the current rate of development in the field of electronics, it obviously is impossible to make such an electronics course comprehensive. However it is believed that the manner in which the subject is treated at the Australian National University goes a long way towards removing the mystery which has for so long surrounded the black boxes used by the scientist. By virtue of this approach the course enables the student to speak, read, and write the ever increasing vocabulary of electronics with a reasonable proficiency.

It is a pleasure to acknowledge the efforts of the workshop staff of the Physics Department who have turned ideas into reality and in particular to thank Mr P. Walsh and Mr L. Batt for their help and advice. The author also wishes to express his gratitude to Professor D. N. F. Dunbar for his many valuable suggestions and his encouragement during the past seven years.

LETTER

Physicists Abroad

Sir:—We wish to comment on the article ‘Employment of Physicists in Australia’ published in the January 1970 issue. The author has obtained information from 43 Australian physicists who are working abroad and who have higher degrees. He admits that this number is not complete but feels it is reasonably representative. He uses this to draw important conclusions on the brain drain and brain gain.

We have compiled a list not from University records but from our personal knowledge of graduates of just one University, Melbourne. We know of at least 48 Melbourne physics graduates working overseas during 1968. Everyone of these graduated BSc and did postgraduate work at Melbourne. Twenty-one completed their PhD at Melbourne or another Australian University, whilst almost all the remainder have obtained or are completing their PhD’s overseas. We acknowledge that seven have since returned to Australia, but can list a larger number who have meanwhile gone abroad. We believe that many more would return if suitable jobs were available.

From this we believe that the brain drain is much higher than indicated by the author and that the number of PhD’s seeking jobs in Australia in the future will be higher than estimated.

3 Peak Street, Engadine M. J. KENNY
and J. R. BIRD
24 Cumbee Lane, Caringbah, NSW.

The information contained in this letter has been forwarded to Mr Argy, who has indicated that he is following up this matter before offering an official reply for publication—Ed.
DO WE UNDERSTAND ALL ABOUT OUR OWN GALAXY?

Sir Richard Woolley
Astronomer Royal

Quite obviously we cannot know every detail about our own galaxy: what I really mean is, do we know enough about our own galaxy; so much, in fact, that there is no great pressure on us to find out more, and, in fact, it is a lot more exciting to inquire about other galaxies and leave our own alone. Quite a lot of astronomers act as if this was really so, and in the sense in which I now put it, they would answer ‘Yes, we do understand all about our own galaxy.’

If we are going to discuss this question at all, the first thing to do is to assemble all the things we know, or suppose we know, about our own galaxy and then perhaps we can say it is an all perfectly sound doctrine and true knowledge, and it is quite enough too, let’s get on to other galaxies and to pulsars and quasars. On the other hand if our ideas about our own galaxy are not above suspicion as to their correctness, it might seem rather important to get them straight: not perhaps before inquiring elsewhere, but at least as a matter of considerable interest and even of urgency.

Start by defining what the Galaxy is. It is practically everything that you can see in the sky at night with the naked eye, but there are a few exceptions as one can see in this hemisphere the Magellanic Clouds, which are not a part of it, and in the North you can make out the Great Nebula in Andromeda if you know where to look, and that is another galaxy rather like our own but a long way away from it—and of course enormous numbers of galaxies can be seen on photographs taken with large telescopes.

If the Galaxy consists of all or nearly all the stars you can see, and all the bright strip of light comprising the Milky Way, what can we say about its shape and its size? What can we say about its motion? And is there anything whatever that we can say about its history?

Herschel the elder formed a distinct idea of the Galaxy nearly two hundred years ago. He made what he called star gauges, by simply counting the number of stars he saw per square degree in various directions in the sky. He found that these numbers increased markedly from a certain region which can be called the North Galactic Pole towards an equator which is roughly the Milky Way. Later William Herschel’s son, John Herschel, went to the Cape of Good Hope and made similar counts in the southern skies, and these confirmed his father’s conclusion that the stars are distributed in a thin lens-shaped distribution, of which we are in the outer parts. We can call this lens-shaped distribution ‘the Galaxy’ and the equatorial plane is called ‘the plane of the Galaxy’. We, of course, see more stars when we are looking in the galactic plane than when we are looking away from it: that is to say towards the North and South Galactic poles—with the important exception that there are some areas in the sky in or near the galactic plane where we see nothing at all. A good one is the Coal Sack, a black area just next to the Southern Cross and about the same size as the Cross. We do not think that there are no stars in this direction. Actually you can see just one with the naked eye, and it is a good test of your eyesight to look for it. But the Coal Sack is black not because it is a hole in the stars but because it is a great patch of absorbing matter—dust—lying in the Milky Way and hiding, or partly hiding, the stars behind it.

The Milky Way looks bright, and when it is looked at with a powerful telescope most of the brightness can be seen to be due to very large numbers of faint-looking stars. However, not all of the light of the Milky Way comes from stars, and some of it comes from clouds of gas.

The Galaxy is, then, a great disk composed of stars, of gas, and of dust, of which our sun is just one star, moving in the outer parts of this great system.

Herschel, of course, had not the faintest idea how large the Galaxy was. This is the year of the bicentenary of Captain Cook’s first voyage, a voyage which was specially commissioned to observe the transit of Venus, in order to determine accurately the distance from the Earth to the Sun. This expedition was successful and Herschel certainly knew this distance to rather better than about five per cent: but the distance from the Sun to the nearest star was not to be determined until 1838.

I had better interpolate the remark here that the knowledge that there are other galaxies than our own is comparatively recent. In 1920 it could still have been argued that there is only one galaxy, ours, the Milky Way. This view was disproved by the distance measurements that must now be described.

We come back to the stellar distances measured first in 1838. Distances can be measured by surveyors by triangulation. You can find the height of a top of a mountain without actually going there, by laying out a measured baseline and measuring the angles of a triangle. This method could be and is applied to astronomy, if suitable baselines can be found. In the case of the
distance from the Earth to the Moon the baseline used is the diameter of the Earth and the triangulation is rather easy, because the angle at the apex of the triangle—where the Moon is—is about one degree, if the radius of the Earth is the base of the right angled triangle: and of course one can measure one degree with very good accuracy. This angle at the vertex is called the parallactic angle or more shortly the parallax. In the case of the distance from the Earth to the Sun the parallax is just under 9 seconds of arc, a much harder angle to measure, and the transit of Venus was used in 1761 and 1769 to find this angle by an ingenious method proposed by Halley in 1716.

One would like to do the same for the stars, but these are so very distant that the parallax using the earth's diameter as a base is only a hundred thousandth part of a second of arc and triangulation absolutely impossible were it not for the fact that we can use a much bigger baseline—the diameter of the Earth's orbit round the Sun. We know this diameter in kilometres when we know the solar parallax. What you have to do is measure the position of a nearby star in summer and in winter (or spring and autumn as the case may be), relative to a background of faint stars which you know to be much further off. The nearby star will shift its position, on account of the fact that you are observing it from stations at opposite ends of a diameter of the Earth's orbit—and so you get the stellar parallax, the angle subtended by the radius of the Earth's orbit to the star. It is always very small, in fact it is less than one second of arc in the best known cases, which is why its measurement was too difficult for eighteenth century astronomers to accomplish.

In the best known cases, stars whose parallax is greater than one tenth of a second of arc, there is no doubt about the phenomena or their interpretation, and we can say that we know stellar distances in such cases with an error of only a few per cent. However there are only about a hundred stars which we know to have parallaxes as large as this, and if the parallax is much smaller than a second of arc—say, if it is a third of a second of arc—it is hard to measure it with accuracy and if it is a tenth of a second of arc we cannot measure it at all by the direct trigonometrical method. Here I must introduce the parsec. Distance is proportional to the reciprocal of the parallactic angle. It is very convenient to take as unit distance that distance at which the radius of the Earth subtends exactly one second of arc. This distance is one parsec. Then if the parallax is one tenth of a second of arc, the distance is ten parsecs, and so on. We can tell distances with reasonable certainty up to twenty parsecs by the direct trigonometrical method, and beyond this the parallaxes become uncertain progressively in such a way that if a star is 100 parsecs away the distance determined from a trigonometrical parallax is worthless.

A sphere of radius 20 parsecs is tiny in comparison with a whole galaxy, and we should know very little about the size of the galaxy if much more powerful means of determining distance were not available to us. These methods exist, and are based almost entirely on the inverse square law of the intensity of light. This simply states that the further off a given light is, the fainter it looks, the amount of light received being inversely proportional to the square of the distance. Consider the amount of light you get on a piece of paper from a lamp 10 feet away. If you moved the light to twice the distance, 20 feet, you would have to have four bulbs to get the same intensity, and so on.

It follows that you can tell how far off a star is if you measure how bright it looks, provided you know how bright it really is. And indeed if all the stars were in fact exactly the same in brightness it would be a simple matter to find the distances of the closest and brightest ones by trigonometrical parallax and then say how far off the fainter ones are. Those at 10 parsecs distance would be 100 times as faint as those at 10 parsecs.

The argument is however quite useless as it stands, as the stars in fact are very unequal in brightness. Sirius, the brightest star in the sky, is only about 3 parsecs away, but the next brightest star, Canopus, is at least 50 parsecs away. As it looks nearly as bright as Sirius, it is in fact a great deal brighter in itself—or, as we say, its luminosity is much larger. Indeed the known range in stellar luminosity is more than 10 000 to 1, and you cannot find stellar distances from apparent luminosities until you find the absolute luminosities.

The situation is saved by the fact that means exist for determining the absolute luminosities. There are two main ways in which this can be done. One, if the star happens to be a variable star of a special kind, its luminosity can be found from the period of its light variation; and, two, the spectrum of a star can be made to reveal the star's absolute luminosity. Generally speaking the first method is the better, but it is confined to special stars, while the second method has a very wide application, but does not give a very precise result.

This method has the great advantage that it works perfectly well however far off the star is: in the remotest part of our galaxy, in the Magellanic Clouds, in other galaxies, but for one thing—interstellar absorption. Lights don't look so bright in a fog, and there is an interstellar fog, the dust which is quite obvious in the dark lanes in the Milky Way and persists in smaller amounts practically everywhere. To get proper distances, we have to allow for the effects of interstellar absorption. Secondly, one has got to calibrate the scale of luminosities as a function of the period of the star, or in other words one has to find a zero point of the period luminosity relation. This is not too easy, since there are not variables of the bright sort close enough to us to show really good trigonometrical parallaxes.

I don't want to spend too much time on discussing the methods of calibrating the period-luminosity law. As it applies to the Cepheid Variables, which are pulsating stars with periods greater than one day, the best method is an appeal to the half dozen cases where Cepheids occur in clusters of stars whose distance is supposed known by other arguments, and it leads to a result which should not be in doubt by more than a
quarter of a magnitude. An error of 1/4 magnitude in the zero point means about a ten per cent. error in the distance scale.

Difficulties over absorption are severe in some directions and rather minor in others. One has of course to assess the absorption in every case and the standard method of doing this is to observe the colour of the star and compare it with the colour of a star of the same type in a region where there is supposed to be no absorption. This is because the dust reddens as it absorbs, in the same way as particles reddens the sky at sunset. What is not certain is the value of the ratio of reddening to total absorption, and whether this ratio is the same in all parts of the sky. But one may say that application of the period-luminosity law ought to give distances with rather better than ten per cent. accuracy.

If we have this means of measuring very great distances, tens of kiloparsecs, how could we set about determining the distance from the Sun to the centre of the Galaxy?

There are in the sky a number of very rich clusters of stars, of which a very good example is ο Centauri. There are about eighty of these objects known. Each consists of a large number of stars, 100 000 or so, and they present interesting problems concerning their structure and their equilibrium, but the important point about them in connection with the size of the galaxy is that Shapley was able to determine their distances from the Sun. He did this in three ways. Firstly, about a third of them contain variable stars—and this permits a direct determination of the distance if there is no absorption and if the absolute magnitude of the variable is known. For those which showed no variables, Shapley assumed that the brightest stars in all globular clusters were about the same absolute magnitude, and he equated the absolute magnitudes of the bright stars in the globular clusters which had no variables in them to the absolute magnitudes of the globular clusters which did have variables—and so he got distances from the Sun, whether there were variables or not. Lastly, some clusters were too far off to be resolved into individual stars reliably, and to determine the distances of these, Shapley assumed that the diameters of all globular clusters were the same. Then if a cluster appears to have one tenth of the diameter of another, it is ten times as far distant. In this way Shapley estimated distances of all the globular clusters known to him, and he argued that they were symmetrically distributed in the Galaxy and that the centre of the system of globular clusters was the centre of the Galaxy itself. Indeed we can confirm Shapley's supposition or at least make it plausible by examining galaxies other than our own. Hubble showed that ours is not the only galaxy; by his celebrated work with the 100-inch telescope Hubble was able to prove that the spiral nebulae are complete galaxies quite separate from our own. Recently Dr Allan Sandage has published The Hubble Atlas of Galaxies which contains beautiful reproductions of photographs many of them made with the 200-inch telescope on Mount Palomar. Two of these NGC 4486 (Messier 87) and NGC 4594 (Messier 104) are accompanied by a conspicuous system of globular clusters. In these two cases one can well suppose that if one succeeded in locating the centre of the globular cluster system, one would succeed in locating the centre of the galaxy. If one found a symmetrical system of globular clusters in our own galaxy and fixed its centre, one may suppose that one would have located the centre of our own galaxy.

The method works in observing our own galaxy because globular clusters are seen well away from the plane of the galaxy, in which the heavy obscuration lies, so that one can see a globular which is the other side of the centre from us, because it lies above the galactic plane. Shapley's estimate of the distance to the centre of the galaxy was 16 000 parsecs or 16 kpc, which one would now want to amend to about 10 kpc, on account of corrections arising from what absorption there is, and on account of a modification of the absolute magnitude of the variables from the figure adopted by Shapley.

There are other methods of determining the distance to the centre of the galaxy, one at least of which is very difficult to apply on account of the necessity of making a rather large correction for absorption. The best value to adopt for the distance to the centre is 10 kpc, but we should not be completely surprised if a better determination based on new observations or on a quite new method, not yet conceived, showed that the true value differed from this by a kiloparsec.

Size alone tells us nothing about the mechanism of the Galaxy, let alone its history. We must inquire into the motion. This we can do by investigating in detail the motion of those stars which are quite close to us; by investigating one component, the component in the line of sight, or radial velocity, of stars at any distance from us; and through the techniques of radio astronomy, of which Joe Pawsey was a pioneer, of the same component in the motion of hydrogen gas.

The distinction between the nearby stars on the one hand, and the distant stars and all the gas clouds on the other, arises because transverse motion is only measurable in the case of nearby stars. It can only be ascertained by comparing the present position of a star with a former position: this is an angular displacement, and of course for a given velocity in kilometres per second this is the smaller if the star is further away. In practice transverse motions are usually uncertain if they relate to objects 100 pc distant and worthless if objects are a kiloparsec or more distant. On the other hand the radial velocity, the component of motion in the line of sight, is measured by the shift of spectral lines (the Doppler Effect) and this is the same whatever the distance of the object.

Having determined as much information as we can about the motions, relative to the Sun, of component parts of the Galaxy, such as individual stars and gas clouds, what interpretation can we place upon the results?

A classical question consists in inquiring whether the Galaxy is rotating as a whole. To answer this, we must set up a reference frame, and in practice this could be
one of two kinds. We might succeed in setting up a reference frame within the solar system by observing the planets and finding that they defined two invariant planes, such as would serve to define a frame within which we could say that the system was indeed rotating. This has of course been attempted and is to some extent effective.

The other plan would be to define a reference frame by means of external galaxies, so far distant that their annual angular motion is much smaller than the angular motion of the galaxy. This latter course is being currently pursued and there are some indications that it will soon provide the best reference system.

Short however of detecting actual rotation relative to an inertial frame we might hope much more easily to observe differential rotation of the various parts of the galaxy, the inner rings slipping round faster in angular motion than the outer rings. This is what the planets do in the solar system. Venus has a shorter year than the Earth, and Mars a longer one. Venus gains on us in heliocentric longitude, and we in turn gain on Mars.

This differential rotation appears as a change in the mean radial velocity as a function of galactic heliocentric longitude: it is proportional to the distance of the star and is easily detected in the case of the B stars which are intrinsically bright and therefore reasonably far distant.

In the simplest theory the component of radial velocity due to differential galactic rotation is

\[ \rho = 2A \pi \sin \lambda \cos \beta \]

where \( \lambda \) and \( \beta \) are the heliocentric galactic longitude and latitude of the star, the centre of the galaxy being the zero of heliocentric longitude. Values of \( A \) have been determined many times, and the most favoured experimental results have dropped in recent times from 20 km s\(^{-1}\) kpc\(^{-1}\) to about 14 km s\(^{-1}\) kpc\(^{-1}\).

At present the only available determination of the absolute rotation depends on the setting up of fixed planes in the solar system, the equator and the ecliptic. Actually both of these planes move, but it is the aim of planetary theory to establish invariant planes based on these two.

The best value is about 0.005 2\(^\circ\) per year, a rate of rotation which has a period of 250 million years.

These results can only be reduced to a form which is of any use to us by an appeal to a theoretical model. The most famous model, and one which still dominates the field, is the model put forward by Lindblad and by Oort which supposes that the mean velocity of the stars (or rather certain classes of stars) is the circular velocity. If the attracting force is radial, acting towards the centre of the galaxy, then there is at any distance from the centre a velocity such that the centrifugal force exactly balances the attraction, and a star having this velocity, moving perpendicular to the radius to the centre of the galaxy, goes round in a circular orbit. This defines the circular velocity, and if we can find stars which move in this way and get the constants of galactic rotation from them, we can find the mass of the galaxy—provided we know the distance to the centre of the galaxy. The best values available at the moment are:

- circular velocity 250 km/s,
- distance to centre 10 kpc,
- attracting mass of Galaxy \( 4 \times 10^{10} \) g,
- \( = 2 \times 10^{11} \times \) mass of Sun.

This important piece of information is not likely to be very greatly in error, but it cannot be regarded as certain as, for example our estimate of the mass of the Sun. This is partly because the distance to the centre of the galaxy may be wrong by as much as ten per cent. and the circular velocity could be wrong by more than ten per cent.

The uncertainty, however, can even be greater than these percentage errors would suggest, because the theory which assumes that the galactic force is radial to the galactic centre ignores the attractions due to the spiral arms, which must distort the attraction and may give it an appreciable tangential component in our neighbourhood. At the moment, the observational material on which a working model of the field could be built is very sketchy, and the theory of a non-radial field has not been developed.

Apart from the question of the size and motion of the Galaxy as a whole, and the deduction of the mass of the Galaxy from these, many features of stellar motion can be observed which have, ultimately, a bearing on the history of the Galaxy.

The subject was given a significant advance by Baade who photographed one of our nearest neighbours, the great nebula in Andromeda, with long exposures in the war years when the lights of Los Angeles were blacked out and the sky over Mount Wilson Observatory was very dark. Baade found that the brightest stars near the centre of this galaxy were red in colour, whilst the brightest stars in the outermost parts were blue.

Baade developed the idea of two stellar populations, applying not only to the stars in the Andromeda nebula but also to the stars in our own galaxy: one population characteristic of the centre of the Galaxy and the galactic halo, and the other characteristic of the galactic disk. By the last two phrases one means that most of the stars in our own neighbourhood are confined to a thin sheet stretching two or three hundred parsecs on either side of the galactic plane and these form the disk population, whereas the scattered stars which lie outside the galactic plane (and of course the globular clusters) form the galactic halo. Indeed some stars, like blue giants and typical Cepheid Variables, hug the galactic plane very closely, most of them being within one hundred parsecs on either side of it. This close concentration of the disk population to the galactic plane, and its great preponderance over the halo population, is the reason why we see so few stars in constellations like Coma and Bootes which are well away from the galactic plane.

Now it is observed that, statistically, the disk objects have small velocities relative to the Sun, while the halo...
objects have, statistically, high velocities relative to the Sun. But the Sun itself has very nearly the circular velocity, so that this general division is a division into disk objects which all have the circular velocity of 250 km/s round the galaxy with a scatter of 10 to 30 km/s around it, and halo objects which have not got the circular velocity. We are streaming ahead quite fast round the Galaxy accompanied by a cloud of stars the disk stars who are doing the same thing, and these seem slow moving to us. But we and the disk stars pass through the halo stars and leave them behind; they only seem fast movers.

Now there are a lot of stars (the Galaxy has an attraction of $2 \times 10^{11}$ solar masses) and each star is attracting every other star, but in fact they are so far apart on the average that they interfere very little with each other's orbits, even in the accumulated time of $10^{19}$ years at which we may put the age of the Galaxy (deduced from the age of the Earth and from detailed arguments about stellar constitution). So those stars which start out with nearly circular orbits will continue to describe very similar orbits even if they go round the Galaxy a hundred times. But stars are formed from gas. There is plenty of gas in the Galaxy still uninformed into stars; it was first revealed by lines in stellar spectra, the interstellar lines, and can now be seen by 21-cm radio astronomy. The particles in this gas cannot move about independently of each other. Gas is sticky stuff: if two gas clouds meet, they have to coalesce and share their motion. In more technical language we can say that the mean free path of a star is many times the dimensions of the Galaxy, but the mean free path of a gas particle is small in comparison with the size of the Galaxy.

A little reflection will convince one that gas clouds cannot describe elliptic orbits without having collisions and changing their motion, and that the only way for gas clouds to go round the galaxy without colliding with each other is for all the gas clouds to go round in circular orbits. Also, gas clouds cannot weave up and down across the galactic plane without striking each other; gas has to stay pretty close to the galactic disk. So, if you want to form a star now, you must form it out of present-day gas, and present-day gas has got the circular motion and stays close to the disk. It follows that recently formed stars, which have the motion of the gas from which they were condensed, must have nearly circular orbits, and must hug the disk. Our argument leads to the conclusion that disk stars are new stars and halo stars are old stars, formed before the galactic gas had had time to order its motion.

The argument receives considerable support from the spectra of the stars. It may be supposed that the original state of the gas in the Galaxy was hydrogen, and that the more complex elements are built up by nuclear processes which only occur at the centres of stars. The gas which we see now is quite heavily contaminated by metals, and indeed the first interstellar lines to be observed were calcium lines. We know that some stars suddenly become novae and supernovae, and we can suppose that by these and perhaps more violent processes the heavier elements are spewed up from stellar interiors and scattered about interstellar space. Accordingly the old stars may have been formed from nearly pure hydrogen, and the newer stars formed from a contaminated mixture. Should this show in the stellar spectra? Not if the old stars had formed the metals in their own interiors and transferred it to their surfaces; but it is likely that there is a good deal of stratification in stellar interiors, so that the metals in the interior do not easily get to the surface. We now argue that old stars should have metal poor spectra and the newer stars metal rich spectra. It is not so easy as one might think to find out the metal content of a stellar spectrum—not as easy as determining impurities in a laboratory specimen, and an elaborate analysis is called for. These analyses are being made currently, and they do support quite generally the division into new and old stars which is given by dynamical argument.

We can now ask how the variable stars fit in the scheme. All stars can pulsate, but this does not mean that they will in fact do so. A piano string is tuned to a particular note, but it does not sound unless it is struck, and then the sound dies away quickly. In making the noise the string has to do work against the surrounding air, and in the course of time the energy given to the string by striking it is dissipated and the note dies. To make a continuous note it is necessary to keep on supplying energy to air vibration, as in continually blowing a violin string or in some electronic device where energy is continuously fed into an oscillator. Now many Cepheid variables have been seen to pulsate for at least fifty years, or five thousand cycles of the variable, without any observed diminution in the pulsation, so the damping must be very small indeed or else there is energy fed into the oscillation. We suppose that stars which do not pulsate are damped like a piano wire, and stars which do pulsate have got some mechanism which feeds energy into a pulsation once it gets started. Eddington, who opened up the theory of pulsating stars, thought that the source of pulsation must be a nuclear one at the centre of the star, but he seems to have realized that this was not necessarily so in his last paper on the subject, and now it is thought that it is the behaviour of the star's atmosphere which is responsible for pulsation. One may liken the star to a kettle on the hob. Energy is fed into the kettle at a constant rate from below, yet the lid bounces up and down. Pressure is built up which raises the lid, and when the lid is up, steam escapes and the lid falls until pressure is built up again and the cycle is repeated. It is something like this in the atmosphere of a star, and the pulsating stars are those with ill-fitting lids and the others have as it were lids with an escape valve. A star starts out without this bouncing mechanism, but it has to change its form because it uses up all the hydrogen at its centre, building it up into higher elements and so developing a core in which a new reaction takes place; but the presence of the core alters the entire structure of the star and in particular alters the stellar atmosphere, permitting the pulsation mechanism to operate. The
star goes on being a variable for a very long time until further changes in the interior cause adjustments in the surface conditions which destroy the pulsator.

Now the typical Cepheid Variables, with periods more than one day, hug the galactic plane and have nearly circular velocities. They are therefore new stars, and are going through a pulsation stage in the star's history, which occurs comparatively soon after its formation. On the other hand the short period variables occur in a comparatively late stage in the star's history, and this means that such variable stars are old enough to have been formed in the early stages of the history of the Galaxy, when the gas was by no means reduced to circular motion. Such stars (the RR Lyrae variable stars) still describe the highly elliptical orbits, often steeply inclined to the galactic plane, that they first described when formed from the disordered gas, and they therefore appear as fainter stars to us, who have the orderly circular motion.

The most concrete suggestion about the formation of the Galaxy was put forward a year or two ago by Sandage, Eggen, and Lynden-Bell, these authors supposing that the Galaxy was formed by the collapse of a much larger structure—a gaseous one, of course. The outer parts in falling to the centre do so mainly in a radial direction, that is a fall from all points towards the centre. But this centring cannot have been exact; we know that the Galaxy rotates so that it has an angular momentum that it must have had in its expanded state. We can however suppose that the gas clouds fell in highly elliptical orbits, not distributed quite at random but with a preference for that direction in which the Galaxy now rotates. It must have been capable in these first stages of condensing into very large star clusters, since the globular clusters are all very old; they are high-velocity objects and they are also old objects. There are individual stars which have similar motions and they too were formed in the first stages of the Galaxy, either in clusters which subsequently broke up or formed individually. The picture is completed by the presence of some groups of stars with intermediate kinetic properties—that is with orbits which are by no means circular, yet not too highly elliptical, and inclined to the galactic plane but not excessively so, as if they were formed when the gas clouds had settled down a bit, but not to their present state of hugging the galactic plane and hugging the circular velocity.

Further work remains to be done, of various kinds. It is probable that a galactic magnetic field plays some part in controlling the gas motion, it is possible that serious galactic explosions took place after the original collapse and started up some fresh radial motions. Large classes of variable stars (especially the Semi-Regular variables) have not been placed in the scheme at all: their kinematic properties are unknown and the mechanisms in their atmospheres are obscure. Yet it seems unlikely that the contemporary picture of the mechanism of the Galaxy and of its history will be completely set aside by subsequent discoveries, and the development of this theory, together with the development of the theory of stellar evolution by the study of actual nuclear processes in stellar interiors, the two being linked in many ways, represent the major advance in ordinary astronomy, the astronomy of optical telescopes and typical stars, that has taken place in the postwar years.

KEITH MEREDITH BURROWS

Born 22 February 1927, died 21 December 1969
Born in Perth, Dr Burrows enrolled at Melbourne University in 1947, transferred to Western Australia in 1949, and graduated with First Class Honours in Physics in 1951. He then took employment as Scientific Officer in the Defence Standards Laboratories, travelled overseas to hold a temporary position at the Admiralty Research Laboratories in 1954, and returned to DSL for a further year.

In 1956 he joined the British Petroleum Company in WA as Production Planner, and two years later went to IBM as applied science representative.

He was appointed lecturer in the School of Physics, University of New South Wales, in July 1959. In 1964 he became a Senior lecturer, and held this position when he was killed, together with his wife Dorothy and only child Adrian, in a car accident while travelling to Perth.

He had obtained his doctorate in 1964 and was leader of a research group working on the determination of atomic collision cross-sections by modern techniques. The year 1967 he spent as a Visiting Fellow at the Joint Institute for Laboratory Astrophysics at Boulder, Colorado. After his return, he obtained substantial support from the ARGC for his research.

During his years at the University, Keith established a reputation as a fine lecturer at all levels of Physics teaching, in particular in the Honours programme, for which he prepared several series of outstanding lectures. As Chairman of the School's Syllabus Committee he contributed notably to the revised courses introduced in 1968. As a member of the Faculty of Science Executive he worked vigorously to ensure the effectiveness of this important body.

Both in his teaching and research, he was noted for his enthusiasm, coupled with an uncompromising attitude towards accuracy and thoroughness.

He was a man of wide-ranging interests, yet with a devotion to Physics. No one who knew him could fail to appreciate his charm, good humour, and generosity. His death will be felt as a great loss by both his students and colleagues.
Editorial

With the advance of science, more knowledge is accumulated and disseminated in scientific journals and through proceedings of conferences. Conferences have become the exchange where scientists and technologists meet to test new fundamental ideas and concepts, and to keep abreast of equipment developments and advances in technique. At national and international meetings they provide mutual benefits for all—speaker and audience alike. In vacuum science and technology, the conference where a lecture can be brilliantly executed and rounded off by animated discussion, is presently very popular among vacuum workers.

National Conference

Realizing the potentialities of a conference, the Vacuum Physics Group will be staging the Second National Symposium—Exhibition, 24-26 August 1970 at which we are going to have Dr L. Holland, the international thin-film vacuum scientist to open it. Plans for the event are already under way with bookings for a lecture theatre and exhibition area at the Chemistry School, University of Sydney, and for a reception—a buffet dinner on Monday, 24 August 1970. Accommodation for interstate visitors has been booked at International House, University of Sydney, and a visit on Wednesday afternoon, 26 August, to a very large vacuum plant is being considered. At present, eleven firms have promised to exhibit, and it is anticipated that some of the very latest equipment from local and overseas manufacturers will be on display.

In response to the ‘Call for Papers’ in the November Australian Physicist, the Committee has received six replies, and three others have been promised. Please let Dr J. W. Kelly, Hon. Secretary have many more; abstracts on Thin Films would be particularly welcome. We will endeavour to publish the papers, as before, in ‘Vacuum’.

Your Committee enlists your full support in an endeavour to make this Second National Symposium—Exhibition a worthy event.

Conferences around the world

On the international scene, one interesting conference took place in France last year; others are expected to take place in a number of countries in the months ahead.

In December 1969 at Grenoble, the French Society of Vacuum Engineers and Technicians held an international colloquium on Vacuum and Cryogenics which was devoted to such subjects as: physico-chemical phenomena at low temperatures and pressures, theory and practice of desorption, measurement of vacuums at low temperatures, techniques for measurement of pressure in simulated space environments, performance analysis of condensation pumping, vacuum and cryogenics in space research, and conservation of living organisms at low temperatures and pressures. The same organization is holding an international congress on thin films, in particular, semi-conductor and metal oxide films, at Cannes, October 1970. Information can be obtained from the Sécrétariat de la SFTTV, 19 rue du Renard, 75 Paris 4e, France.

The Vacuum Metallurgy Division of the American Vacuum Society is organizing an international meeting at Anaheim, California on 15-19 June 1970.

The 7th International Symposium on Rarefied Gas Dynamics is expected to be held at the University of Pisa, Italy on 29 June-3 July 1970.

In 1971, the 5th International Vacuum Congress is expected to take place in Washington. The Congress Organizing Committee has asked our Committee to act as liaison between them and the Vacuum Physics Group. Information can be obtained from Mr J. D. Mellor, Chairman, AIP Vacuum Physics Group, CSIRO Division of Food Preservation, PO Box 43, Ryde, NSW 2112.

Sectional Notes

New South Wales

The NSW section met on 17 March to hear a lecture on Teaching of Vacuum Science and Technology by Mr K. G. Stewart, Physics Department, New South Wales Institute of Technology. Mr Stewart’s subject dealt with a formal course in vacuum science and technology that is being set up at the New South Wales Institute of Technology which it is hoped will satisfy the widely different requirements of those who use a vacuum environment.

South Australia:

The inaugural meeting of the South Australian Section took place at the University of Adelaide on 10 December. To mark the occasion, Professor J. C. Kelly, School of Physics, University of New South Wales gave a talk on ‘Electron and Proton Bombardment of Solids and the Vacuum Systems Involved Therein’, in which he discussed the use of electron and proton beams and the vacuum systems involved for a number of purposes such as the measurement of the surface tension of liquid metals, the growth of single crystals, the determination of the orientation of crystals, and the measurement of radiation damage.

News Items

A new method of vacuum freeze drying, called ‘cyclic-pressure freeze drying’ has been developed in the CSIRO Division of Food Preservation.

The method depends on the application of surges of air pressure in the drying chamber, which result in more efficient heat transfer for the sublimation of ice in frozen foods. Then, as the air is drawn off by a vacuum pump, the water vapour sublimes from the ice crystals. The surges of pressure are repeated throughout the process and reductions in drying time of up to 30 per cent. in commercial plant have been obtained.
CSIRO has patented the process and a commercial prototype has been built by the Australian licensee James Budge Pty Ltd of Sydney. This unit is now operating and being used by CSIRO and industry to assess the full potential of the process and the cost savings possible.

This company has recently received several contracts for freeze-drying equipment, the design of which has been used on research carried out in the Division of Food Preservation. One freeze dryer, with a drying shelf area of 250 ft², is being built for the Defence Food Research Establishment of the Department of the Army, Scottsdale, Tas. It will consist of a vacuum chamber, 6 ft diameter and 12 ft long, housing a liquid heating system and a condenser of special design cooled by a refrigeration plant of 22 ton (−40°F) capacity. A vacuum pumping system will continuously pump the chamber at the rate of 1700 ft³/min (0.1-1.0 torr). This freeze dryer is expected to be installed and operating by the end of 1970.

Technical Information

Phonic Desorption

Various methods of supplying energy have been used for the desorption of gases from metal surfaces in vacuo. Electron impact, photon interaction and pulsating gas leak have been used. Desorption can also take place when a system is phonoically or acoustically excited, for instance, by deliberately striking a system under vacuum, a pressure burst will be observed. To investigate phonic desorption, an ultrasonic transducer was mounted on an all metal ultra-high vacuum system containing a quadrupole residual gas analyser to determine the gaseous species evolved. The vacuum system was diffusion pumped and throttled with an orifice of 12 l/s conductance for nitrogen. In this way the pumping speed for each of the gases was known. Without the orifice, a cryogenic trap in the pumping line would give somewhat higher speeds for condensable gases. The ultrasonic transducer, a 50W, 40kHz device was attached to a flanged cover to the vacuum chamber with a centre bolt. About one watt of power was estimated to be acoustically coupled into the system. The system was baked for about three hours at 300°C to bring the base pressure of the system low enough to ensure observance of the desorption process against small effects in background pressure. After baking, the system was cooled to room temperature and the cryogenic trap kept cold. After ten hours steady state was established.

The gas analyser detected methane, carbon monoxide, carbon dioxide and water vapour. When the ultrasonic device was turned on the partial pressures of the first three gases measured by the analyser changed from $10^{-4}$ to $10^{-6}$ torr to $10^{-9}$ to $10^{-10}$ torr in 5-6 min. The behaviour of water vapour was strikingly different from the other gases, and its partial pressure changed from $2 \times 10^{-7}$ to $1 \times 10^{-5}$ in about ten minutes.


Plasma Arc Cutting Equipment

Stainless steel has important applications in the construction of high and ultrahigh vacuum systems and components. It was therefore of particular interest to the vacuum technologist to hear that a company in Australia has installed plasma arc cutting equipment. This machine can cut up to 5/4 in thick sections of stainless steel and aluminium up to 4/4 in thick sections of copper. Plate can be cut to any profile directly from the customers' simple line drawing. Tests indicate that the heat affected zone in which the metallurgical properties of the stainless steel are altered, only extends for 0.005 in from the plasma cut edge. To use this service to produce flanges from sheet stock, rather than from bar stock which involves an inherent risk of fibrous porosity, is but one interesting possibility.


Aluminium for Ultrahigh-Vacuum Systems

In the wake of the Bayard-Alpert ionization gauge developments in the 1950's, a new pumping mechanism was discovered which meant the attainment and measurement of ultrahigh-vacuum pressures from $10^{-7}$ down to $10^{-10}$ torr. With the bake-out of the components of a vacuum system and the use of better materials for construction, some further improvements have been obtained.

Aluminium instead of stainless steel for construction seems to be a good choice because of its lower diffusion and permeation rates for atmospheric gases, but there are problems of melting and fabrication. It has been largely neglected in vacuum technology because of its high porosity and gas-content and its relatively low strength at high temperature. On re-examination, it is noted that aluminium has for years been used as a cladding material for electron-tube electrodes, and has a hydrogen solubility lower than any other metal that is commonly used for construction purposes. As molten metal aluminium behaves in reverse, thus on solidification a high gas-content and porosity remains, with pockets and blowholes that are subsequently rolled or extruded into long fine capillaries. On the other hand, vacuum-melted aluminium should have a greatly reduced porosity and gas content. And to overcome the low strength at high temperature aluminium might be fabricated under vacuum; it would then require only low temperature bakeouts.

Another way of overcoming the fabrication problem whilst making use of the desired properties of aluminium, would be to form composite metals by cladding or evaporating thin films of aluminium onto the surfaces of stainless steel vacuum components. A vacuum deposited film $10^{-3}$ cm thick would reduce the hydrogen diffusion rate by about $10^4$ times. Moreover, aluminium has a hydrogen permeability at room temperature about $10^4$ times lower than stainless steel.


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CHANGES IN MEMBERSHIP FROM 13 MARCH 1969 TO 14 APRIL 1969

FELLOWSHIP

Resignation
Coombe, R. A. (SA)

ASSOCIATESHIP

(a) New Elections
Abeyasekere, W. D. M. University of Melbourne, Vic.
Henson, P. W. Royal Perth Hospital, WA.

(b) Transfers
Latz, C. V. Bedford Park Teacher’s College, SA.
Muffatti, A. H. J. Bureau of Meteorology, Melbourne.
Powell, K. R. Commonwealth Industrial Gases Limited, Alexandria, NSW.

GRADUATESHIP

(a) New Elections
Horsfield, R. S. University of New South Wales.
Larsen, P. D. Bentley Senior High School, Bentley, WA.
Lewis, D. B. University of New England, Armidale, NSW.
McMahon, D. R. La Trobe University, Bundoora, Vic.
McNeill, A. R. B. Department of Supply, Antarctic Division, Melbourne, Vic.
Mills, G. R. University of New South Wales.

Palmer, E. M. Electricity Commission of New South Wales.
Pockett, J. D. BALM Paints Limited, Clayton, Vic.
Seppelt, B. M. University of New England, Armidale, NSW.
Sweet, D. R. Flinders University of South Australia.

(b) Transfers
Attrens, A. University of Adelaide, SA.
Docking, R. A. Wesley College, Prahran, Vic.
King, W. D. University of New England, Armidale, NSW.
Oliver, L. D. King’s College Hospital, London, UK.

STUDENTS

(a) New Elections
Barnes, C. A. (Qld) Bryce, M. E. (WA)
Gilbert, B. V. (Qld) Hart, D. N. (SA)
Jones, B. C. (NSW) Kirecenow, G. (WA)
Lad, J. A. (NSW) Lim, K. K. (Vic.)
McLaren, R. E. (NSW) Moynihan, G. C. (Qld)
Rapkins, G. E. (Qld) Rokić, D. (Vic.)
Stumer, L. J. (Qld) Willock, E. C. (WA)
Winter, A. C. J. (Qld)

(b) Resignation
Balzer, L. A. (SA)

SUBSCRIBERS

Resignations
Adelaide Girls’ High School (SA) G. R. Johnson (Vic.)
M. L. Kaye (NSW)

NOTES AND NEWS

Honorary Degree

Members will be pleased to learn that Mr J. L. William, who has done so much for the Institute—particularly in the organizing of instrument exhibitions, is to be awarded an Honorary Master of Science degree by Monash University. This is in recognition of his pioneering work on high precision electrical instrumentation in Australia and his valuable contribution to research at Monash.

International Physics-Program Library

An international physics-program library has recently been started at the Queen’s University of Belfast with the aid of a grant from the Science Research Council, London.

The programs, written in an international source language, are contributed by leading physicists from laboratories and institutes all over the world. Detailed descriptions of the programs are given in a new journal called ‘Computer Physics Communications’ published by North-Holland Publishing Company, Amsterdam, and the library is stored and indexed on magnetic tape and disc files on the Queen’s University ICL 1907. Retrieval programs are being written to allow information on any program in the library to be rapidly accessed.

The Belfast library distributes programs on request to two classes of user. Institutes and laboratories can become subscribers and receive, on magnetic tape, a copy of every program that comes into the library. As well, an individual physicist can request a copy of a
single program or a few programs. A charge is made for these services to cover handling, but the library is non-profit making. It is hoped that the publication and distribution of programs, as well as reducing the costly duplication of programming effort, will enable authors to obtain appropriate recognition for their work, and will promote rapid advance in the use of computers and computing techniques amongst the physics community.

As the number of programs in the Belfast library and the need for their rapid distribution grows, it is intended to start other libraries forming a network in Europe and in the USA. Several institutes have already agreed to collaborate in this way and will be supplied from the central library at Belfast.

Further information, including details on how to become a subscriber to the Belfast library, can be obtained on request from Professor P. G. Burke, Queen’s University, Belfast.

BOOK REVIEWS


Reviewed by K. E. Bullen, Department of Applied Mathematics, University of Sydney.

There now exists a large body of well-determined information about the interior of the earth, and while many assumptions still need to be made in applying this information to outside bodies, the modern approach to knowledge especially of the moon and the terrestrial planets is principally through geophysics and geochemistry.

The book under review follows this approach—an approach which has already become many-sided, as indicated by the wide range of topics the book touches on. Examples are: background information on geochemistry, petrology, structural geology, lattice-vibration theory, geochronology, age of the earth; mathematical theory on seismic-wave transmission, the figure and gravity of the earth, and on thermodynamics and heat flow; the dynamics of the earth-moon and the solar system; internal distributions of density, pressure, compressibility, rigidity, and gravitational intensity; internal phase transitions; anelasticity and convection currents; evidence from artificial satellites; magnetic fields of planets; planetary surfaces; geology of the moon and Mars, meteorites and tektites; questions of planetary origins and compositions.

The approach is a firm mathematical one and a desirable quantitative spirit is evident even in the less mathematical topics. This makes the book eminently readable and satisfying to physicist and applied mathematician readers. Much of the mathematical detail adheres extremely closely to the earlier parts of previous standard formulations, but it is convenient to have this material from well-reputed sources assembled in a single book. Where assumptions have to be made, the author selects his favoured line, usually uncritically, which he then follows consistently. This makes for tidy presentation, and the selected lines are indeed generally of high repute and up-to-date. But the impression is given that certain of the results are more cut-and-dried than they are. Somewhat too narrow a line is followed, for example, on certain aspects of the earth’s density distribution.

Nevertheless, this is an excellent book. As an introduction to a subject which demands insight into many separate disciplines, it is about as good a book as any single author could be expected to contrive. The inclusion of well-chosen set exercises at the end of each of its nine chapters enhances its value. The book is strongly recommended as a third- or fourth-year level text-book in all Australian undergraduate departments where geophysics or planetary physics is taught. It is also recommended to all those who wish to be informed on the general shape of current knowledge of the interiors of the earth and terrestrial planets.


Reviewed by G. V. H. Wilson, Physics Department, Monash University.

This book will certainly be welcomed by all who work with magnetic materials. The first part (Chapters 1–10) is a review of the intrinsic magnetic properties of a vast array of magnetic materials including the transition metals and their alloys and compounds, rare earth and actinide metals, ferrites, and garnets. The data in these chapters is well presented with many diagrams and a very wide coverage of both materials and properties, although the authors do point out the obvious difficulties in their choice of material for inclusion. A very pleasing feature is the use of comprehensive and up-to-date lists of references.

The second part deals with technical properties such as permeability and switching times, which depend not only upon the intrinsic properties but also upon sample structure and preparation. The treatment here is more descriptive and again good use is made of many diagrams and reference lists. This should prove to be very useful to those with an applied interest in magnetic materials. Those who concentrate more on pure research should not ignore it either.

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The aim of Chapter I appears to be to teach magnetism to the relatively uninitiated. I feel that the range of standards covered here is too wide with some inaccuracy then forced upon the authors as they attempt such an ambitious aim in about 40 pages. A better solution might be a guided tour of existing elementary texts. However this is but a minor blemish in such an excellent book.

To summarize this is not a textbook but a comprehensive handbook which will prove to be invaluable in all laboratories in which magnetic materials are studied.


Reviewed by Moira J. Walsh, Presbyterian Ladies College, Pymble, NSW and Ravenswood Methodist School for Girls, Gordon, NSW.

This book is a welcome addition to the limited number of up-to-date general physics texts available for high-school students. The level is suitable for the present first level and second level (full) Physics courses taught in fifth and sixth forms in New South Wales. The excellent illustrations and diagrams, many of them original and unusual, together with the general clarity of style in presenting physical concepts, will make this an attractive book to students and teachers alike.

The mathematical treatment is at an elementary level—no calculus has been used throughout the book. In certain sections, for example, wave motion and rotational mechanics, the absence of calculus has led to statement of formulae rather than derivation, making the sections incomplete as far as a first-level student is concerned.

A lucid historical account of the development of atomic theory and the energy quantum includes many interesting personal glimpses of the physicists concerned. Some aspects of the Pauli principle have not been included, notably the application of the principle to covalent bonds and the magnetic properties of transition elements. The chapters are arranged in sections, ending with a good selection of problems, but no references are provided for further reading.

In summary, this is a valuable general text, very well presented and illustrated, and suitable for students of first and second level (full) senior Physics. I would recommend this book for the library of any school offering these courses.


Reviewed by J. R. Bird, AAEc, Lucas Heights.

Nuclear Electronics as a technique began in the early thirties when physicists seized upon the possibility of using vacuum tubes to ease some of the tedium of counting nuclear events. Later developments introduced methods for the measurement of pulse height, time, and logic decisions such as coincidence or anti-coincidence between pulses. These techniques provided the springboard for the development of digital computers as well as the very sophisticated equipment now used in nuclear measurements.

Basic Nuclear Electronics claims to ‘bridge the gap between mathematics and application’ in this field by devoting half the book to a discussion of basic principles and the other half to a description of typical systems. The first half is well set out and easy to follow. It deals with circuit elements, networks, amplifiers, basic logic circuits, etc. The exposition of basic principles continues through the second half of the book also, but is somewhat hidden amongst the description of devices such as an oscilloscope, pulse-height analysers, etc. Thus, although the index is quite helpful, a lot of useful information (particularly on practical problems) is difficult to find.

A second limitation arises from the description of equipment largely from the experience of one laboratory. This would have been less noticeable if included as illustrations of general principles rather than vice versa. Also, such is the pace of development in this field, that the particular systems described will eventually become obsolete. In fact, such is the pace of book production that this process is already evident. Nevertheless this is undoubtedly a useful book particularly for users who are willing to treat their equipment as something more than a black box.
GENERAl: The Organization’s Division of Physics operates a number of modern solar and astronomical instruments as part of the CSIRO Solar Observatory at Culgoora. The optical observatory is on the same site as the Division of Radiophysics’ radioheliograph. The appointee will be required to reside at Narrabri, N.S.W. and to work a five day week including some weekends. Transport to and from the Observatory is provided. A Commonwealth house is available for rental.

DUTIES: To assume responsibility for the routine operation of three small solar telescopes used for a flare patrol and recording prominences and chromospheric velocities, together with the analysis of flare patrol and other records.

QUALIFICATIONS: A degree in science or equivalent qualifications. Experience in astronomy, electronics, or optics, would be an advantage.

SALARY: Depending upon qualifications and experience, the appointment will be made within the salary range of Experimental Officer Class 2, 86.151-86.908 p.a., or Class 3, 87.264-88.130 p.a.

Applications, quoting reference number 770/405, and stating full name, place, date and year of birth, nationality, marital status, present employment, details of qualifications and experience, together with the names of not more than four persons acquainted with the applicant’s academic and professional standing, should reach:

The Chief, Division of Physics, CSIRO, University Grounds, City Road, CHIPPENDALE, N.S.W. 2008, by 29th May, 1970.

AUSTRALIAN ATOMIC ENERGY COMMISSION RESEARCH ESTABLISHMENT, LUCAS HEIGHTS, NEAR SYDNEY

SOLID STATE PHYSICISTS

Two vacancies exist within the Solid State Physics Section for Research Scientists:

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(ii) to work in the field of magnetism or lattice dynamics using neutron diffraction techniques.

For the first position the applicant should have some mathematical ability plus a knowledge of diffraction theory, since the position involves analysis as much as experimentation. The successful applicant will be expected to set up and use a computer-controlled X-ray diffractometer.

For the second position previous experience in diffraction, or magnetism, or lattice dynamics, is necessary. The successful applicant will be expected to initiate research work in magnetism or lattice dynamics, and to collaborate with outside users of the neutron diffraction equipment.

Applicants must possess a Ph.D. (or postgraduate research experience of equivalent standard and duration) supported by satisfactory evidence of research ability.

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