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R. LAKIN
DEPUTY COMMONWEALTH STATISTICIAN
AND GOVERNMENT STATISTICIAN OF TASMANIA

include: (i) the Tasmanian Collection—a definitive collection of books published in Tasmania; (ii) the W. E. Crowther Library—a large research collection of books, pamphlets and other items relating to Tasmania and Australia; and (iii) the Allport Library and Museum of Fine Arts—comprises a collection of antique furniture, china, glass, silver, pictures, prints and rare books in fine editions.

Archives Office: The *Archives Act* 1965 made this library department the official repository for all official State Government records. A considerable quantity of private records of individuals, companies, associations, societies and institutions is held as well as official records.

Division of Unregionalised Services: This division supplies books and other library materials to, and co-ordinates library services in, those libraries which are not yet part of the regional library system. There are over 40 of these libraries.

Hobart Lending Library: Provides a book lending service for adults and children. Approximately 107 000 volumes are held in this collection.

Films and Recorded Music Library: Contains over 5 000 films and almost 50 000 gramophone records and 8 000 cassette tapes. Films and records are available for borrowing by individuals and organisations.

Regional Libraries

There are two operating regional library systems in Tasmania—their headquarters are at Launceston and Burnie. It is planned to regionalise the whole State into a total of six library regions by 1978.

Launceston: Headquarters of the Northern Regional Library Service are located at the new Launceston regional library building which was opened in mid-1971. The Northern Regional Library Service serves the City of Launceston and Municipalities of Beaconsfield, Campbell Town, Deloraine, Evandale, Fingal, Flinders, George Town, Launceston, Lilydale, Longford, Portland, Ringarooma, Ross, St Leonards, Scottsdale and Westbury. Branch libraries are located in small towns of the region; rural areas are served by two bookmobiles.

Burnie: The Hellyer Regional Library Service comprises the Municipalities of Burnie, Circular Head, Penguin, Waratah and Wynyard and was inaugurated in 1965. A central library for the regional service is located at Burnie. Reference, lending, bookmobile and external services are provided for the region. A new regional library headquarters building was opened at Burnie in January 1975.

ASTRONOMY IN TASMANIA

The following article was contributed by Dr M. D. Waterworth, Physics Department, University of Tasmania

Introduction

No one who looks at present-day studies of the universe can fail to be impressed by the remarkably detailed foundation of theory and fact that has been established, nor by the soaring, imaginative structure erected on top of it. Consider some of the questions that astronomers and cosmologists are now asking: How big is the universe? What is its shape? When did it start? When, where and how was its matter manufactured? Was all its material present at the beginning or is it being continuously created? These are no longer mere expressions of child-like curiosity. They are meaningful queries to which science expects—and is getting—answers.

It is now generally agreed that the universe is expanding; that groups of galaxies are rushing away from each other with speeds which increase with the separation between them. There is, however, a sharp division of opinion as to the history of this expansion. One school holds that it started at a definite moment, some five or six billion years ago, with the explosion of a super-dense blob containing all the matter in the universe. The other view is that the expansion has always been going on at just its present rate, and that it will continue to go on for evermore with new matter being continually created to replace the old matter that is moving away.

The first, or evolutionary, theory is expounded by George Gamow. He discusses the various possible forms of an evolving universe. It may be closed and finite or open or infinite. It may have ' begun ' in an infinitely expanded state in the infinite past, contracted once to a minimum size and then started to expand again; alternatively, it may have contracted and expanded cyclically an indefinite number of times. The second view is put forward by Fred Hoyle, one of its leading exponents. He demonstrates the mathematical logic behind the rather startling steady-state theory, and explains how the question may soon be decided.

One of the pieces of evidence that will help settle the matter is the red shift, from which the fact of expansion was deduced. The more distant the galaxy, Allan R. Sandage explains, the farther its light is shifted toward the red end of the spectrum. This shift is interpreted as a Doppler effect, which means that the source of light is moving away from the earth. Still to be determined is the relation between distance and velocity for very remote galaxies. The light from these galaxies takes a billion years or more to reach us, and so we see them as they were a billion years ago. If their velocity is proportionately greater than for nearby galaxies, this will indicate that the expansion of the universe is slowing down, which would mean an evolving system rather than a steady state.

Another test depends on the density of galaxies. If they were closer together a billion years ago than they are now, the universe must be evolving. Jerzy Neyman and Elizabeth L. Scott describe how the comparative densities can be determined through statistical analysis. Martin Ryle tells us that radio signals will enable astronomers to extend their tests to much greater distances than those accessible to optical telescopes.

The modern cosmologist has a great deal of solid observational evidence to work with, but he is still forced to make rather sweeping assumptions. In particular, he must believe that the section of the universe he can see is a fair sample of what lies beyond his view.

Present Day Astronomy in Tasmania

Based on the Introduction above, one could easily be led into believing astronomy to consist very largely of optical astronomy. This may have been so in the early days, but is by no means true today. Astronomy today deals with radiation at wavelengths in the range from less than 10^{-10} cm to 3×10^4 cm (from X-ray astronomy to long wavelength radio astronomy). In Tasmania work is carried out in the wavelength range 10^{-8} cm to 3×10^4 cm, covering X-ray astronomy, cosmic ray astronomy, optical astronomy and radio astronomy. In reporting on activities here, one must therefor cover all these branches of the subject. What follows then, is a description of activities in these branches.

It should be emphasised that the individual branches of astronomy are not separate entities. The results obtained from, say, radio astronomical measurements are co-ordinated with results from other wavelength regions, and in many cases this leads to a greater understanding of what is going on. I believe this to be a strong factor in Tasmania's advantage, since most of the work here is carried out by members of the one institution, the University of Tasmania.

Radio-Astronomy

Tasmania is particularly suitable for observing extra-terrestrial radio sources at the longer radio wavelengths (2×10^3 cm to 3×10^4 cm) which are normally prevented from reaching the ground in most parts of the world owing to the opacity of the earth's upper atmosphere to such signals. However, a region of low ionospheric electron density exists at middle latitudes in the Southern Hemisphere in a band roughly concentric with the south Geomagnetic pole. This mid-latitude ionospheric trough passes over Tasmania during the winter in years of low sunspot activity and allows observation of the lower frequency signals which otherwise can only be made using radio-telescopes in space. The telescopes themselves need to be large in size (about 1 km) in order to discriminate between different sources, and so far have been practicable to construct only on the ground.

Over the past 20 years, a number of low frequency radio telescopes have been built in Tasmania to take advantage of this natural facility. The latest instruments are the University of Tasmania 650 m × 650 m Llanherne array operating between 2 MHz and 20MHz and the 1 km diameter 1.1 MHz Bothwell array (Dr G. Reber). There are also two other telescopes operating in the 40-2 000 MHz range at Llanherne. These are the 170 m × 85 m broadband array and the 15 m parabolic telescope.

The observational program includes investigations of the radio emissions of our galaxy and of extra-galactic sources, of pulsars, and of solar system sources such as the Sun and the planet Jupiter. The two low frequency telescopes, which are the largest of their type, are used mainly for observing the galactic radio emissions which are strongly absorbed at long wavelengths by interstellar ionised hydrogen regions. The detection and location of these regions provides basic information on the structure and evolution of the galaxy. The 650 m × 650 m telescope is also by far the most powerful so far used to record the radio emissions of Jupiter and very large amounts of data on the properties of these signals and of the radiation and magnetic environment of Jupiter have been obtained.

Investigations of the galactic pulsating radio sources are being made on the same telescope and, in addition, a novel technique based on two-dimensional Fourier Transforms has been developed to detect previously unknown pulsars. This has been used with the 65 m C.S.I.R.O. Parkes radio telescope to discover nine new pulsars, and in the near future will be used with the 170 m × 85 m Llanherne telescope. The large size of the Tasmanian telescopes permits a high rate of data acquisition and the solar, Jupiter and pulsar radio observations are aimed at the investigation of their fine time structure and at understanding the corresponding radio emission phenomena.

Cosmic Ray Research

The first studies of cosmic rays in Tasmania were made by Professor A. L. McAulay and Miss N. L. Hutchison at the University of Tasmania, the results of the work being presented to the Royal Society of Tasmania in December 1924 in a paper entitled 'The Penetrating Radiation in the Atmosphere at Hobart'.

In 1946 further studies were commenced by Dr A. G. Fenton at the then new site for the Physics Department at Sandy Bay. A grant from the Electrolytic Zinc Company provided the funds for the early experiments. Others who were involved in the first few years of these investigations were Dr D. W. P. Burbury, Dr. K. B. Fenton, Dr N. R. Parsons and Dr R. M. Jacklyn. By 1949, with renewed

Australian interest in the Antarctic, the University group, in co-operation with the Antarctic Division of the Department of External Affairs, constructed equipment for operation at Macquarie Island. This was installed on the island in 1950 and various cosmic ray experiments were conducted there until the building was destroyed by fire in 1959. Larger equipment was designed and built at Hobart and, by the time the Australian base at Mawson on the Antarctic Continent was ready to commence its scientific program in 1955, some of the largest cosmic ray detectors in the world were installed there.

In 1956 a recorder was installed near The Springs on the slopes of Mt Wellington to take advantage of the increased altitude. This recorder was destroyed in the bush fires of 7 February 1967, and has since been replaced by a larger recorder at the same site. During the International Geophysical Year 1957-58, cosmic ray recorders were operated by the Hobart group at Lae (New Guinea), Hobart, Macquarie Island and Mawson. Later, a recorder from Sydney University was handed over to the Hobart group and, after rebuilding, this was installed in Brisbane. Following the fire at Macquarie Island, it was decided to transfer cosmic ray recording operations to Wilkes on the Antarctic Continent because of its close proximity to the geomagnetic South Pole.

In 1958 underground measurements were commenced for the purpose of extending observations to much higher energies. For these, the tunnel on the disused Sorell railway near Mt Rumney has proved suitable and the measurements are being continued at the present time. In 1971 even deeper measurements were commenced at the Hydro-Electric Commission's underground power station at Poatina where the overburden is about 150 metres of rock (compared with about 15 metres at the tunnel).

During 1959 measurements were commenced using small balloons launched from the University. These high altitude observations were later extended, often in co-operation with other bodies, to Macquarie Island and Wilkes in the Antarctic, as well as to Mildura, Brisbane, Lae and Hyderabad to take advantage of the greatest possible range of geomagnetic latitudes. Measurements were also made on aircraft through the co-operation of the Royal Australian Air Force during the International Geophysical Year 1957-58.

In 1971 the University was host for the 12th International Conference on Cosmic Rays. On this occasion delegates from many parts of the world held their first such meeting in the Southern Hemisphere.

Cosmic rays are now known to consist of high energy atomic nuclei (mainly hydrogen nuclei or protons), with energies extending up to more than 10^{20} electron-volts. There are also high energy electrons as well as X-rays and gamma-rays. It is not known with certainty where the particles originate and one of the principal objectives of research in Tasmania, as well as elsewhere in the world, is to obtain information concerned with this problem. Because the particles carry an electric charge, they are deflected by magnetic fields, which are known to pervade all of our Galaxy, and consequently the direction of arrival of a cosmic ray particle at the Earth gives no clue as to the direction of its source except at the very highest energies. However, it is believed that some cosmic ray particles are accelerated during supernova outbursts which occur from time to time in the Milky Way Galaxy and in other galaxies.

The Sun occasionally produces bursts of energetic particles during periods of solar activity. Several of these have been observed by the network of recorders operated by the Hobart group. The Sun also effects the cosmic rays of galactic origin, and the study of this effect is one of the main research topics of the Hobart group. It is now known that a continual stream of hot gas leaves the Solar corona in all directions (i.e. the solar wind) and that this has magnetic fields embedded in it. The combination of solar wind and magnetic fields deflects the cosmic ray particles, resulting in fewer being able to penetrate into the solar system during disturbed times than during quieter times. Cosmic ray intensity follows the Sun's 11-year cycle of activity.

The type of equipment used by the Hobart group consists of arrays of Geiger-Muller counters, or similar detectors. Some of these are particularly sensitive to neutrons (which are produced in the atmosphere by cosmic ray particles causing the disintegration of oxygen and nitrogen nuclei). Most of these detectors and the electronic circuits used with them have been designed and built in Hobart.

There were two main reasons why cosmic ray research was initiated at the University. Firstly, it provides a means for training students in some aspects of nuclear and particle physics at much less cost than would be possible otherwise. Secondly, the geomagnetic latitude of Hobart was favourable for some of the early investigations, while, for later ones, the network operated from Hobart played (and continues to play) a vital role in the world-wide network for monitoring cosmic rays.

Although very few direct applications of cosmic rays to the welfare of mankind have emerged so far, the study of cosmic rays has contributed significantly to knowledge about the structure and properties of matter and about the processes by which energy is generated and stored in the Universe.

Financial support for the Hobart group has come from the University of Tasmania research funds, from the Australian Research Grants Committee, from the Antarctic Division (formerly of the Department of External Affairs, now of the Department of Science), and, during the International Geophysical Year, from special funds administered by the Australian Academy of Science.

X-Ray Astronomy

An important turning point in high energy astrophysics occurred in 1962 when a U.S. group discovered X-rays emanating from star-like objects in the Galaxy. The Hobart cosmic ray group extended its observations into this field in 1966, jointly with the University of Adelaide, where Professor K. G. McCracken, a former member of the Hobart group, was then forming a research group. Through the co-operation of the British Science Research Council, the British Aircraft Corporation and the Department of Supply, space in several Skylark rockets was made available for X-ray detection systems constructed by the Hobart and Adelaide groups. The rockets were launched from Woomera, South Australia.

With the first rocket, launched on 4 April 1967, a new and exciting source was discovered near the Southern Cross and later called Centaurus-XR2. This was a very powerful source, second in intensity to the brightest X-ray source (Scorpius-XR1). Subsequent rocket flights by the joint group and by other observers showed that the new source was diminishing in intensity. This was, thus, the first discovery of a variable X-ray source and the first discovery of what is now called an ' X-ray nova '. The mechanism which operates on an X-ray nova remains unknown.

Altogether the joint group has participated in eight rocket launchings from Woomera, seven being British Skylarks and one an Aerobee on which space was generously made available by the U.S. National Aeronautics and Space Administration. Much detailed information on the properties of X-ray sources was obtained from these flights, supplementing the information obtained by rocket, satellite and balloon by other research groups, particularly in the U.S. and U.K.

It is now believed that some of the X-ray sources consist of two stars in orbit about each other (a binary system) with one of the objects being very highly compressed—a 'compact' object—such as a neutron star or a black hole. A neutron star, for instance, has a mass comparable with that of the Sun but a diameter of perhaps 10 km. Matter passes from the other partner to the compact object and gains such high energy in falling onto it that X-rays are emitted.

Optical Astronomy

Optical astronomy has been carried out in Tasmania for many years, and recently has been undertaken at the University. Many amateur astronomers have made observations in the past with their own small telescopes and to this day the observations are continuing. Interest appears to be growing in this field of astronomy, and much of this growth of interest may be attributed to the ready availability of instruments.

Particular mention should be made of the Amateur Astronomers Association of Tasmania. This is a group of enthusiastic astronomers gathered together in order to discuss their observations, results and problems. One member, Mr C. Bisdee, has been very active within the Society, and the continuing existence of amateur astronomy is due, in no small part, to his efforts. It would be a lengthy procedure to discuss the activities of all amateur astronomers in Tasmania, so this will not be attempted here. I would, however, congratulate them all on their activities, and hope they will continue for many years to come.

Optical astronomy at the University has really existed for the past twelve years or so. The University's association with optics in general, however, dates back many years to the time of the Second World War. At this time, Australia was without its own source of optical munitions. The former Professor of Physics, A. L. McAulay, and his associate, Dr F. D. Cruickshank, were involved in the initial inception of such an industry, and were contracted to design many items of optical equipment for the then Department of Supply. The production of the optical munitions was carried out by the Hobart firm of E. N. Waterworth.

In post war years, work on optical instrumental design was continued by Dr Cruickshank and Mr G. A. Hills, and in the latter stages this work included the design of optics for telescopes. In 1963 work was commenced on the construction of an 0.4 metre optical telescope. The interest taken here in optical astronomy was due largely to the stimulus provided by an American astronomer, Dr Theodore Dunham Jr, who at that time had just retired from a research position at the Australian National University. Interest here in optical astronomy also followed naturally from the University's interest in optics, radio astronomy and cosmic ray astronomy.

The 0.4 metre telescope was entirely designed at the University and all mechanical parts were constructed by University personnel and by local industry. The mechanical design is based largely on the design of the 5.08 metre Hale Palomar telescope. Optics for the telescope were ground and polished by Mr W. E. James, who was employed by the University until 1968. It is interesting to note that both the mechanical and optical construction turned out to be much better than anticipated, so much so that in 1968 it was decided to use the telescope for professional optical astronomical research as well as for the training of students.

It is also interesting to note that Mr James now has a very successful optical business in Victoria—he has secured many contracts which have been tendered on a world-wide basis, not the least of which have been several contracts for the 3.8 metre Anglo-Australian Telescope.

In 1968, following the return of Dr M. D. Waterworth from overseas, the 0.4 metre telescope was installed at the University's observatory site at Canopus Hill (adjacent to Mt Rumney) near Cambridge. The telescope was used initially for direct photographic work and for photometric work. (This is the determination of the ' colour ' of a star by measuring the radiation emitted by the star in a number of wavelength intervals: U, ultra violet; B, blue; and V, visual, are three of these wavelength intervals.) Photometric observations permit one to determine the type of star that is being observed and give some information about its temperature, size, age, and stage of evolution.

The 0.4 metre telescope, being a small instrument, is only useful for observations of relatively bright objects in the sky. Astronomers are limited to stars brighter than about 12th magnitude with this instrument, but with a 3.8 metre telescope, for example, one can observe stars of 24th magnitude, this being about 1/250 000 as bright as a 12th magnitude star. For this reason, Tasmanian astronomers make use of facilities at Mt Stromlo Observatory in Canberra, and the Siding Springs Observatory at Coonabarrabran.

From a scientific point of view, many of the photometric observations made with the 0.4 metre telescope are of considerable interest. Observations of variable stars have revealed objects with intensity variations of the order of minutes in some cases and hours in other cases. The mechanisms of these variations is not yet fully understood, and further observations plus theoretical analysis must be carried out.

The photometric work carried out with this telescope includes the determination of the optical radiation from X-ray stars. These stars, in general, emit excessive amounts of radiation in the blue wavelength part of the optical spectrum. Part of the observation of these objects involves the location of the optical object corresponding to the X-ray star. In some parts of the sky this is difficult because of the large number of stars present, and because of the uncertainty of the X-ray star's position caused by instrumental limitation of the X-ray detectors. A further problem is that the X-ray stars are usually relatively faint at optical wavelengths.

Another photometric observation which has been attempted with the 0.4 metre telescope is the optical identification of pulsars. This type of work has been attempted by many astronomers around the world but with very little success. Again the 0.4 metre telescope is too small to detect the optical counterpart of pulsars, assuming that they exist. (The only optical pulsar identified so far has been the Crab pulsar.)

In 1971, a further facet of observation with the 0.4 metre telescope came into operation, namely the spectroscopic observation of stellar objects. The aim of this type of observation is to determine the chemical composition and abundance of elements in stellar atmospheres. This enables one to infer the nuclear reactions taking place beneath the surface of the star and hence lead to a better understanding of the evolution of stars, planets, and man himself.

To obtain the spectrum of a stellar object light from the object is split into its various colours using either a prism or a diffraction grating. In this mode of operation, the telescope acts solely as a collector of light, while the grating, in combination with extra mirrors and lenses, produces the spectrum which is then recorded either photographically or photo-electrically.

The 0.4 metre telescope has been used to obtain the spectra of many stellar objects. Of particular interest has been the study of so-called F-supergiants; these are stars a little younger than the Sun, but are cooler and larger than the Sun.

They do not lie in the normal evolutionary sequence of stars and are therefore of particular interest to astronomers. Many metallic elements, such as Calcium and Iron, appear in the spectrum. Currently spectral observations of O-stars and B-stars are being made. These are much hotter and younger stars than the Sun, and consequently their spectra are more difficult to interpret. Theoretical work done here does, however, promise to help this analysis considerably.

In 1970 work commenced on the design and construction of a 1 metre telescope. Work on this has progressed now to the state where the instrument is now fully operational. Weather conditions, at first sight, may not appear to be sufficiently good to justify the installation of a telescope of this size near Hobart, but it turns out to be a better site than the site at Mt Stromlo, near Canberra, where hitherto most optical astronomy in Australia has been carried out. On the average, Hobart receives 1 350 hours of clear night sky per annum, which enables a lot of observations to be made.

The 1 metre telescope has been entirely designed in Hobart by University personnel, together with much assistance from Mr K. Rhodes of Drafting Services Ltd, Hobart, and Mr H. Newton of Fowler, England and Newton, Hobart. Construction of all the major components has been carried out by the Ordnance Factory in Bendigo, Victoria, and by Rowe Engineering of Hobart. The building to house the telescope has been financed by the Australian Universities Commission.

The 1 metre telescope at Canopus Hill will be used for similar work to the 0.4 metre telescope on the same site, but will be able to observe much fainter objects.