1975QJRAS..16..444H

Q. Jl R. astr. Soc. (1975) **16**, 444–477

THE ROYAL GREENWICH OBSERVATORY

REPORT FOR THE YEAR ENDING 31 DECEMBER 1974

A. Hunter, Director

1 INTRODUCTION—POLICY AND ORGANIZATION

The definition by the Science Research Council (SRC) in January of a new three-fold role for the RGO marked the first formal change in its functions in the 299 years of its existence. The Observatory will continue to carry out research programmes of its own and in collaboration with university astronomers; and it will continue to be responsible for national and international services such as the provision of navigational almanacs and astronomical ephemerides and the maintenance of the national time service. However, the primary objective of the RGO is now the support of university research, particularly by the procurement and operation of large central facilities for ground-based optical astronomy.

As a consequence of its new functions the Equatorial Group of telescopes and the major measuring machines at RGO have now joined the Isaac Newton Telescope as national facilities operated at Herstmonceux for the benefit of all UK astronomers. For a long time it had been recognized that these facilities were inadequate for the requirements of current research in optical astronomy. Thus, in November, the Science Research Council approved in principle the construction of a major new Northern Hemisphere Observatory (NHO) at a superior site overseas. The RGO, in line with its primary role, has been given the responsibility for procuring and operating the NHO, without permanent increase in its complement.

At the beginning of the year RGO was neither adequately staffed nor appropriately organized to undertake fully the new tasks assigned to it. Some measure of internal reorganization was therefore undertaken by the integration of the former departments and research groups and HM Nautical Almanac Office into five new divisions, headed as follows: Astrophysics (Dr. R. J. Dickens—acting); Astrometry and Galactic Astronomy (Mr. C. A. Murray); Almanacs and Time (Dr. G. A. Wilkins); Instrumentation and Engineering (Dr. D. McMullan); Administration (Mr. R. Gordon). In addition, an NHO Project Team is now being assembled under the leadership of the Director Designate, Professor F. G. Smith. On the advice of the Astronomy Space and Radio Board of SRC, a Restructuring Panel

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

has been set up to advise the Chairman of SRC on what changes of staffing and further changes of organization are necessary. This panel, which includes senior staff of the RGO, has had several meetings but has not yet completed its task. However, it is already clear that a substantial increase in the number of engineers will be required.

The RGO complement at the beginning of the year was 256, including 16 designated posts at the Radcliffe Observatory. These posts were deleted from the complement in April, following the termination of the SRC lease of the Radcliffe Observatory and the consequent transfer of most of the staff to CSIR (South Africa) employment. As a result of manpower restrictions affecting all SRC establishments, the complement at 1974 December 31 had been further reduced to 237, including 10 posts reserved for NHO Project Staff. The net result of these changes has been a reduction of 10 in the number of graduate scientists in post. The total number of staff in post at the end of the year was 228½, of whom 100 were members of the Science Group and 26 members of the Professional and Technology Group; there were 98½ industrial and non-industrial support staff and 8½ vacancies, which it is hoped will be filled by engineers early in 1975.

Section 2 of this Report recounts the main activities which have been undertaken in pursuance of the new primary role of the RGO. In addition to the operation of existing telescopes, associated instrumentation has been designed and manufactured and the programme of research and development of electronographic detectors has continued. The reduction in complement, and especially the reduction in graduate staff, has resulted in a progressive reduction of effort devoted to astronomical research. Nevertheless, a wide range of astronomical research activities has continued, as is evidenced by Section 3. The various national and international services and observing programmes are described in Section 4. A brief note of some internal services, not falling under any other heading, is contained in Section 5. Details of staff changes, visitors, etc., are given in Section 6 and the list of publications issued during 1974 in Section 7. An organization chart and list of staff in post on 1974 December 31 are appended.

2 NATIONAL FACILITIES

Northern Hemisphere Observatory

A most important milestone on the road towards the establishment of a British Northern Hemisphere Observatory was passed in November when the Science Research Council approved the general concept of an observatory comprising a 4·5-m telescope, the 2·5-m Isaac Newton Telescope (INT) transferred from Herstmonceux, and a 1-m telescope.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

The estimated capital cost of this observatory is £13M (January 1974 prices), and expected operational costs are £1M per annum. Procurement and operation of the observatory will be the responsibility of the RGO. As members of the NHO Planning Committee, Professor B. E. J. Pagel and, latterly, Professor F. G. Smith, contributed to the formulation of the scientific case for the observatory. Mr. J. D. Pope, assisted by Mr. J. W. Gietzen and Mr. R. H. Adams, prepared detailed cost estimates and timetables for the construction of the telescopes, domes, buildings and site services.

Approval of the project by the Department of Education and Science is necessary and is being sought. In the meantime plans for the assembly of a project team at RGO and detailed design studies and other necessary preliminary activities are already under way under the direction of F. G. Smith.

A decision on the site of the new observatory has still to be made. Under the direction of the Royal Observatory Edinburgh, four possible sites have been tested during the year; four members of RGO staff were seconded to the site-testing teams for several months each.

The Wise Observatory of the University of Tel-Aviv allotted three nights on their 1-m telescope to Dr. D. H. P. Jones to enable a study to be made of the astrometric performance of its Bowen–Ritchey–Chrétien focus, and the suitability of this design for the NHO to be evaluated. Several exposures on Praesepe have been measured on GALAXY and discussed by Mr. C. A. Murray who finds it possible to map one exposure on another with an rms error of about $\pm 2\mu$m. This is true whether the cluster is placed to the centre of the plate, or offset to one corner, and whether the plate was exposed with the sky shield or not. So far only short-exposure plates have been discussed, with the programme stars having a brightness range limited to five magnitudes.

Anglo–Australian Telescope

Commissioning. At the request of the AAT Board, five members of the RGO staff, Dr. R. G. Bingham, Dr. R. J. Dickens, Dr. P. G. Murdin, Professor B. E. J. Pagel and Mr. J. D. Pope each spent six to eight weeks at the AAT assisting the resident staff with the commissioning of the telescope.

Intermediate Dispersion Spectrograph. The assembly of the spectrograph, which is being built at the RGO, was completed and stability tests were carried out on the Isaac Newton telescope. Unfortunately these tests revealed unsatisfactory image displacements. Mr. A. S. Milsom and Mr. P. A. Ellis investigated the causes of these displacements and found that there was flexure in both the grating and collimator

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

mounts; this has been overcome by suitable modifications. Flexure has also been found in the case itself, but attempts to reduce it by local stiffening and by internal counter-balancing have so far been unsuccessful. Expert advice has been sought, and the problem is now being studied by Dr. R. O. Stafford of the Department of Aeronautical Science, Imperial College of Science and Technology, using a computer model which it is hoped will enable a satisfactory solution to be found.

Tests on the electronic control circuits and ancillary units were completed during the year. Modifications to these circuits are still required as a result of the mechanical changes referred to above.

During the year the AAT Board has placed orders with EMI Ltd for a three-stage cascade intensifier, and with Instrument Technology Ltd for two Spectracons. Meanwhile, two universal solenoids for the spectrograph, together with transfer optics and a remotely-controlled plateholder for the cascade tube, and a film applicator for the Spectracon, have been designed and manufactured at the RGO. Manufacture of duplicate electronic equipment was also initiated during the year.

South African Astronomical Observatory

Mark I Unit Spectrograph. Additional equipment for this spectrograph has been manufactured at the RGO during the year. This includes a camera box, housing a universal solenoid, and a Wynne $f/1{\cdot}4$ camera. An EMI three-stage cascade tube has been purchased and given acceptance tests. The completed equipment will be despatched to South Africa in the near future.

Infrared Photometer. Dr. I. S. Glass designed and assisted in the construction of an infrared photometer for the SAAO similar to the existing RGO photometer.

Radcliffe Telescope. At the request of the Director of the SAAO, the Workshop Foreman, Mr. M. Dermody, spent several weeks at Pretoria supervising the dismantling of the 74-inch telescope and turret. He will return to South Africa early in 1975 to supervise the re-erection of both turret and telescope at Sutherland.

Isaac Newton Telescope

Prime Focus. Most of the engineering design for the new prime focus breech end has been completed and the manufacture of the cone, 16-cm plateholder assembly, and solenoid and mounting for an 8-cm electronographic tube has been started. However, pending a decision on the removal of the telescope and the possibility of its conversion to an altazimuth mounting (which would necessitate the redesign of the

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

rotation bearing of the breech end, and possibly the provision of an additional autoguider sensor), the work has been largely suspended.

Coudé Spectrograph. A second grating to give coverage in the red spectral region was delivered in May. Mr. C. M. Lowne has devoted considerable effort to the further investigation and attempted control of the temperature-induced distortions of the spectrograph support beams, which produce unacceptable image displacements during long exposures. On the advice of the Rutherford Laboratory the beams were insulated with 0·25-m thick expanded polystyrene, faced with asbestos and metallized Melinex film. This has had no beneficial effect, the displacements being of the same amplitude as before but delayed by a few hours. A further proposal to build a thermal shield wall around the exposed faces of the enclosure was rejected on grounds of cost. The feasibility of rebuilding the spectrograph as a horizontal instrument was also examined but thermal distortions of the floor made the proposal untenable. The floor distortions also appear to be a cause of the present image displacements. In view of the possible removal of the telescope to a new site no further investigations are being made, since only radical and expensive remedies, including substantial structural alterations, would appear to have any prospect of success.

Mr. C. F. W. Harmer has shown that the Richardson-type image slicer is unsuitable for use with spectrographs having small collimator-to-camera ratios, including the INT coudé.

Mark II Unit Spectrograph. A universal solenoid to house either an EMI cascade intensifier or a Spectracon has been manufactured at RGO for this spectrograph and is expected to be installed early in 1975. Modifications have been made to the existing camera unit to enable the Boksenberg image photon counting system to be used on the spectrograph. Mr. C. F. W. Harmer demonstrated (26) that a suitable field lens would permit more efficient off-axis performance, and such a lens has now been provided.

C. F. W. Harmer and Mrs. D. L. Harmer have investigated the performance of a prototype holographic grating produced at the National Physical Laboratory (NPL) and giving a dispersion of 10Å mm^{-1}. Preliminary results indicate that the efficiency is comparable with the existing 30Å mm^{-1} grating, and tests on the INT have shown that the measured equivalent widths of standard stars are in good agreement with accepted values.

Michelson Interferometer. Development and testing of the Michelson interferometer, designed and built at Imperial College, has been continued by Wayte (Imperial College).

Echelle spectrograph. The components for the Cassegrain échelle spectrograph designed by Learner (Imperial College) were received and

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

assembled under the direction of Mr. C. F. W. Harmer. Photographic tests carried out in the laboratory by Mr. T. G. R. Beynon (research student) revealed figuring errors on the aspheric surfaces. Following several attempts at re-figuring, line widths were reduced to an acceptable figure. Mechanical tests have shown that considerable instabilities exist in the system, but these can probably be corrected by re-design of some of the component mounts.

INT Control System. Work has continued throughout the year, under the supervision of Dr. J. S. Beale, on rebuilding the control console and installation of the NOVA 1200 control computer. The control circuits have been modified and adapted to allow either manual or computer control of the telescope. Moiré fringe encoders have been installed giving digital readout to ± 3 arcsec. The interface required to transfer encoder and clock readings into the NOVA 1200 has been designed by Mr. P. D. Read and built. The control programs have been developed by Beale using a cross assembler running on the ICL 1903T computer. The whole system is now undergoing bench-mark tests using a telescope simulator implemented in software, and installation is scheduled for January 1975.

A new control room is being built on the observing floor to house the NOVA computer and the Interdata 70 instrumentation computer with its peripherals.

Instrumentation Computer. The Interdata computer originally purchased as part of the Imperial College Michelson interferometer has been enhanced to become a general purpose instrumentation computer. The system is now based on an Interdata 70 computer with a disk backing store, a graphics/alpha-numeric visual-display unit and a chart recorder. Magnetic-tape drives are on order. The interface to the instruments is through CAMAC, and branch crates are being installed at the Cassegrain and coudé foci.

"*Seeing*" *Investigation.* Dr. R. G. Bingham and Mr. P. J. Willmoth began an investigation into the causes of the unduly poor seeing reported by Griffin and Argue (Institute of Astronomy, Cambridge). As predicted by Griffin and Argue, poor seeing was found to be positively correlated with excess temperature of the mirror and telescope frame. Several improvements to the building and telescope were devised, but the work has been overtaken by the prospective removal of the telescope from Herstmonceux.

INT Operation. Mr. P. J. Willmoth has continued to manage the operation of the INT. The first three months of the year were affected by the national power crisis and observing was prohibited on 19 nights. However, during the year observing was carried out on 219 nights and 671 spectra, 151 direct photographs, and over 200 other observations

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

were obtained. There was a total of 1138 hours of clear sky; of the 219 nights when observing was carried out, 57 were clear throughout the night, 76 were 50 per cent to 99 per cent clear and 86 were less than 50 per cent clear. The number of instrument changes was 57, in addition to 38 end changes. The stand-down period, June 24 to July 7, was used to modify the wiring of the telescope to accept computer control, to paint certain sections of the dome shutters accessible only with scaffolding, and for maintenance. The primary mirror was re-aluminized three times during the year.

One meeting of the INT Users' Group was held at RGO during the year. In addition to 24 RGO observers and support staff, the meeting was attended by six representatives of outside observing groups. Useful discussions were held on topics ranging from instrumentation problems to bedroom and canteen facilities.

Equatorial Group

36-inch Yapp Reflector. Renovation of this telescope has continued under the direction of Dr. P. G. Murdin. Manufacture of the redesigned Cassegrain secondary mounting is well advanced. An encoder is being fitted to provide remote indication of focus setting. A control room has been built on the dome floor to house an Interdata 70 computer and ancillary equipment, which will be available as a general purpose instrumentation computer. When the programme of renovations has been completed, the facilities at the Cassegrain foci of this telescope and the INT will be entirely compatible. This will be of increased importance if the INT is removed to a distant site. Already, during the past year, the telescope has been scheduled for about 80 per cent of the available time.

30-inch Reflector. Arrangements have been made to provide all the telescope and coudé spectrograph mirrors with broad-band enhanced reflective coatings early in 1975.

26-inch Thompson Refractor. After persistent initial difficulties the autoguider installed in 1972 has performed satisfactorily all year. The "trailed" exposures, sometimes obtained when hand guiding, have been eliminated except for exposures interrupted by cloud.

13-inch Refractor. No major changes have been made to this telescope, which has not been in continuous use.

1-metre Hargreaves Reflector. The telescope was ready for sky trials by February. Mechanical problems encountered in the commissioning tests have been overcome. Astronomical tests made by Mr. P. M. Corben in the Schmidt mode showed considerable aberration, which has been traced to radial asymmetry in the Schmidt corrector plate. Tests are continuing.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

30-inch Steavenson Reflector. Rebuilding of this telescope is well advanced, and it should be ready for installation in Dome C early in 1975. A draft agreement is under discussion with the University of Granada, Spain, under which the telescope will be installed by RGO in a dome provided by the University at the Sierra Nevada outstation of the Cartuja Observatory. It is hoped that the telescope will be operated as a joint University of Granada–RGO venture for an initial period of 10 years.

Coating Plant. An electron-beam gun is being installed in the 40-inch plant. This will enable multilayer reflectance and anti-reflectance coatings to be applied to optical components.

Measuring Machines

GALAXY. Apart from the period of power restrictions, GALAXY has been used for an average of over 400 hours per month. In addition to research programmes for RGO projects and Sussex University students, referred to elsewhere in this report, plates have been measured for Oxford and Cambridge University astronomers, including a large series of Hartmann-test plates from the AAT. Mr. G. M. Harvey has supervised the operation of the machine under Mr. W. Nicholson's direction.

A NOVA 2/10 minicomputer system, with 32K core store, magnetic-tape and disk units and general CAMAC interface has been purchased and will replace the existing paper-tape control system. This will increase the efficiency of GALAXY by eliminating unproductive time currently needed for setting up plates for measurement, and the mechanical troubles associated with the paper-tape medium. The NOVA system has spare capacity which will be used to control the Zeiss Ascorecord and other nearby measuring machines.

Zeiss Ascorecord. The redesigned data acquisition and processing circuits were completed during the year and the equipment tested and commissioned. It has been operational for three months with a very marked improvement in reliability. A considerable increase in operational efficiency is expected when the NOVA computer has been installed, enabling results from plates to be checked as they are measured.

PDS Microdensitometer. A Boller and Chivens PDS computer-controlled microdensitometer and photographic playback system has been purchased and was commissioned by Dr. J. D. H. Pilkington in April. After correction of minor wiring and software faults the system is now operating satisfactorily and has already been used by several university groups and a Medical Research Council team as well as by RGO staff. A simple cathode-ray tube display has been added to allow

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

rapid inspection of the recorded data. The development of improved control software has been started and additional computer peripherals are due for installation in early 1975.

Research and Development of Electronic Imaging Devices

Electronographic Tube Development (34). The problem of photocathode stability has been solved. Dr. D. McMullan and Dr. J. R. Powell have carried out a series of experiments on the effect of oxygen and water vapour on S.9 and S.20 photocathodes. They have confirmed that the pressures of these gases must be considerably lower (10^{-14} to 10^{-15} Torr) than has been previously thought necessary for adequate photocathode life. The improved leak-testing methods that have been adopted have shown up small leaks in the mica windows which were almost certainly a major cause of photocathode decay. A change has been made in the design of the mica-window mounts, and several tubes processed during the year have shown no loss in sensitivity.

Although tube processing was not possible in the early part of the year because of the power crisis, five tubes with 4-cm diameter photocathodes and mica windows are now completed, and three of these have reasonably good performance (S.20 photocathode 120 to 180 μA lm^{-1}, dark current 500 to 2000 electrons cm^{-2}s^{-1} at 20°C). A sixth tube incorporating a silicon diode autoguider sensor is nearing completion. Successful observations have been made using these tubes with the University of Durham polarimeter on the 36-inch telescope.

The first tube with a 10-cm photocathode and 8-cm mica window has been assembled and processed. Its performance is good in every respect except for dark current which is unacceptably high. This problem is being studied by Dr. R. Florentin-Nielsen of Copenhagen University Observatory who is spending six months at the RGO; modifications are to be made to the electrode structure and the tube will be reprocessed.

The electron-optical studies made by Dr. K. F. Hartley (27, 28, 29) have proved to be invaluable for the diagnosis of tube malfunctions.

The testing of Spectracon image tubes manufactured by Instrument Technology Ltd was continued throughout the year by Mr. D. M. Jackson. These included tubes with S.20 photocathodes and larger mica windows produced under SRC contract, and several tubes manufactured for other customers.

Application of Silicon Diodes. Development has restarted on quadrant silicon diodes for use as autoguider sensors in image tubes. Tests have shown that the diodes can be protected during the high temperature (400°C) bake of the image tube prior to photocathode processing. A 4-cm electronographic tube incorporating a diode is now being assembled.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

The Plessey Company Ltd have continued with the development of a silicon chip to be incorporated in an image tube which is being designed at RGO for spectrographic use. The chip has two parallel arrays each of 512 diodes with associated amplifiers, MOSFET switches and shift registers for serial readout. The first samples of the chips have been received and tested on the electron-optical bench. Although these are only partly functional, the detection of single photoelectrons has been demonstrated. Plessey are making improvements in the chip processing and it is hoped that the yield of fully-working devices will be increased. Shift-register stores compatible with CAMAC have been designed by Mr. G. B. Wellgate and built. The completed detector will be operated with the Interdata 70 computer installation at the INT, or at the 36-inch telescope. Software has been written by Dr. K. F. Hartley and Mr. D. J. King.

The Department of Astronomy, Imperial College, has made good progress, under contract from RGO, with the development of silicon–diode arrays (with external amplifiers) which can be brought up to the mica window of a Spectracon in place of an electronographic emulsion. Although a full array of 60 diodes has not yet been operated, the counting of single photoelectrons has been demonstrated on a few elements. The contract terminated at the end of 1974, but the project is being continued following a grant from the Paul Instrument Fund.

General Optics

Mr. C. F. W. Harmer has demonstrated theoretically the importance of correct pupil imagery in the design of astronomical spectrographs, if they are to be properly matched to their parent telescopes (26). He has continued with the development of a general optical ray-tracing program for the ICL 1903T computer.

3 ASTRONOMICAL RESEARCH

X-Ray Sources

Dr. P. G. Murdin and Mrs. A. Savage have made spectroscopic radial-velocity observations of HDE 226868, the optical counterpart of Cygnus X-1, and combined their results with observations made with the satellite *Copernicus* by the Mullard Space Sciences Laboratory (MSSL) X-ray astronomy group. Variations in the flux of Cyg X-1 on the time scale of the orbital period have been observed, with maxima within an hour of the inferior conjunction of the unseen secondary of HDE 226868 (37). Changes in the X-ray spectrum, interpreted as photoelectric absorption of the X-ray source by material in the binary star system, occur near to superior conjunction, but significantly preceding it (36). Observations at optical and X-ray energies continued throughout 1974.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

Mr. E. N. Walker continued his photometric observations of HDE 226868 at the University of Granada observing station in the Sierra Nevada, as part of a joint project organized by NASA. Observations were obtained on 104 nights out of a total of 140 during August to December. Some of the anomalous features previously reported (67) have been confirmed.

Walker has continued his analysis of spectra of HD 153919 taken at the Radcliffe Observatory; spectra taken at the European Southern Observatory have also been lent by the University of Amsterdam. The exceptionally broad emission lines discovered in 1973, whose existence has since been independently confirmed, have been found to be present only when the X-ray secondary (2U 1700–37) of this binary system is out of eclipse. In addition, rapid time variations, with time scales of the order of one hour, have been detected in these lines. The primary star exhibits a single temperature minimum per orbit, the side facing the secondary being cooler. One line of He I shows evidence of large-scale gas streaming (65).

Mr. L. V. Morrison has continued his collaboration with the X-ray astronomy groups at the University of Leicester and the MSSL on the prediction and analysis of lunar occultations observable by rockets and *Copernicus*. From the results of observations made on 1974 October 7 it was found that the diameter of the X-ray source in the Crab Nebula is 73″ and the centroid of the emission is about 20″ from the position of the pulsar.

Dr. B. L. Webster has examined objects near several southern X-ray sources. Possible optical identifications include a high-excitation symbiotic star and a broad-line B star with variable hydrogen emission.

Dr. I. S. Glass has examined a number of candidates for southern X-ray sources at infrared wavelengths.

Extragalactic Studies

Quasars and Seyfert Galaxies. Dr. M. V. Penston and Dr. M. J. Penston have continued their analyses of photometric observations of Seyfert galaxies previously obtained at the Hale observatories in collaboration with Becklin and Neugebauer. The nucleus of NGC 1068 has been found to resemble those of non-Seyfert infrared galaxies like M82 and NGC 253, while other Seyfert nuclei resemble quasars (50).

Dr. D. A. Allen, Dr. R. A. E. Fosbury, Dr. M. V. Penston and Mrs. A. Savage are analysing spectra of 3C 273 and NGC 4151 obtained in collaboration with Boksenberg (University College, London) (UCL) using the INT and the UCL image photon counting system (IPCS), and Mr. H. Netzer (research student) has taken and analysed electronographic and other image-tube spectra of NGC 4151 (43) and a

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

number of other Seyfert-type galaxies mostly taken from lists of Markarian. In 3C 273, a number of new lines has been identified and intensities measured using the IPCS; the line spectrum is fitted by a photo-ionization model with electron density exceeding 10^8 cm^{-3}. In NGC 4151, observed when the continuum was near minimum intensity, Netzer has made the first identification of many weak emission lines, most of them being forbidden lines of iron ions, especially [Fe II]. Weakness of permitted Fe II implies an electron temperature of 6000 K in the outer part of the nuclear cloud, and the state of ionization indicates large amounts of neutral hydrogen. [Fe X] seems to have disappeared after three years, suggesting a small distance from the central radiation source and a possible correlation with variability. Further observations of NGC 4151 with the IPCS have revealed very broad emission lines of He I and permitted Fe II similar to those found in 3C 273.

Broad Fe II lines, comparable in width with the broad Balmer lines, have also been found by Netzer on image-tube spectrograms of Markarian 279, 335, 352 and 486 in which the band near λ4500 is among the strongest features. The results for all Seyfert-type galaxies studied confirm the existence of two components in the nuclei with electron densities around 10^4 and 10^8 cm^{-3} respectively with high velocities and large optical depths in the denser component; the variation in relative strengths of permitted and forbidden lines in different objects is being investigated as a possible effect of evolution.

A theoretical investigation by Netzer of the Balmer decrement in the dense nuclear component of active galaxies using a "mean escape probability" technique shows that large optical depths in Hα lead to significant absorption from level 3 and hence to a steep Balmer decrement that could help to explain the "anomalous" decrements found in most Seyfert galaxies and low-redshift QSOs. This model also predicts an enhancement of Lyman β in optically thick clouds and fluorescent excitation of O I λ8446 which can reach a strength of 0·03 times that of Hα.

Using the INT, Dr. R. J. Dickens, in collaboration with Walsh and Browne (Nuffield Radio Research Laboratory, Jodrell Bank), has started work on a programme of spectroscopy of QSO candidates from the radio survey of the sky between declinations 40° and 70°N carried out at Jodrell Bank. It is hoped to obtain redshifts for a complete sample of about 200 QSOs.

Optical monitoring of quasars, Seyfert galaxies and other radio sources has continued on the 26-inch telescope under the direction of Fosbury and Mr. R. Wood.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

Optical Identification of Radio Sources. Mrs. A. Savage has been working on a radio survey at 2·7 and 5 GHz with the Parkes radio telescope in Australia, in collaboration with Wall and Bolton (Australian National Radio Astronomy Observatory, Parkes). The survey covers a region of about one steradian around the South Galactic Pole, and contains both intensity and position data for more than 800 sources. Searches for optical identifications on Palomar prints are essentially complete for these source fields. Savage is also using IIIaJ plates from the UK 48-inch Schmidt Telescope to search for faint optical counterparts to radio sources which have been surveyed at Parkes.

Optical Positions of Extragalactic Radio Sources. Work on this programme in association with Ryle (Mullard Radio Astronomy Observatory) (MRAO) and Argue (Institute of Astronomy, Cambridge) has been continued throughout the year by Mr. E. D. Clements and Mr. B. S. Carter under the direction of Mr. C. A. Murray. Results for a further 34 fields have now been obtained from plates taken with the 13-inch and 26-inch refractors. Observations of 32 fields requiring INT plates have now been completed and are in process of measurement on GALAXY, while 30 more still require plates from the INT.

Clusters of Galaxies. Further observations of galaxies in nearby rich clusters have been made by Dr. R. J. Dickens and Mr. C. Moss (research student) at the Cassegrain focus of the INT, using the Unit Spectrograph equipped with a three-stage cascade image intensifier. Data reduction for the cluster Abell 1367 (3U 1144+19) is almost complete, and confirms a lower value for the velocity dispersion of this cluster than that required by a thermal Bremsstrahlung model for the X-ray emission from a static intergalactic gas. Data reduction for the cluster Abell 262 (3U 0151+36) is proceeding.

Galaxies. Dr. R. G. Bingham has collaborated with a group led by Scarrott (University of Durham) on the design of a nebular polarimeter which uses the RGO 4-cm electronographic image tube. This instrument, which produces a two-dimensional map of polarized intensity, has been used on M82 in order to provide comparison with previous work. A preliminary analysis of the results by Mr. M. Elvis (research student) has shown the polarization structure with considerably more detail than previously, and has revealed an interesting highly-polarized area close to the centre of the galaxy on the SE side.

Dr. I. S. Glass has extended his programme of *JHKL* photometry of galaxies to include elliptical as well as Seyfert galaxies and ordinary spiral galaxies.

Dr. B. L. Webster and Feast (Radcliffe Observatory) have observed the spectra of probable symbiotic and VV Cephei stars in the Magellanic

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

clouds. The absolute magnitudes of the cool components are comparable with those of normal cool stars.

Supernovae. Spectra and a photographic light curve of the supernova in NGC 4414 have been obtained by Mr. B. E. Patchett and Mr. R. Wood. The spectra, some of which were taken very shortly after maximum light, show that it is of Type I. An unusual aspect of these early spectra is the appearance of a secondary shell expanding at 12000 km s^{-1} compared with 10000 km s^{-1} for the primary shell. There are some indications of the presence of hydrogen.

Clusters and Variable Stars

Globular Clusters. Using the 20-inch SAAO reflector, Dr. D. H. P. Jones has measured the integrated colours of 50 globular clusters on the same intermediate-band system used previously for RR Lyraes, augmented by a G-band measure. As part of the same project he has also measured the dwarf galaxies in Sculptor and Fornax which are only 10 per cent above the surface brightness of the night sky, even at so dark a site as Sutherland.

Stars showing a range of CN strength have been found by Dr. R. J. Dickens in ω Cen. These stars lie along the cool edge of the giant branch and are up to $1^{m}\cdot5$ fainter than the stars at the tip. Analysis has shown that the observed band strengths can be satisfactorily explained by varying degrees of nitrogen enhancement up to about a factor of 30, with little or no carbon enhancement. An important difference between these CN-strong stars and the CH stars in ω Cen is their lack of carbon enhancement. The nitrogen enhancement in the CN-strong stars could be caused by convective mixing from the hydrogen-burning shell occurring in the first or—more probably—a later ascent of the star up the giant branch, but there is no confirmatory information about the C^{13} abundance.

A red-giant member of the globular cluster ω Cen has been found by Dickens to have enhanced barium and strontium lines, suggesting its classification as a type of barium star. Analysis by spectrum synthesis, in collaboration with Bell (University of Maryland), indicates that these two elements are overabundant by as much as a factor of 30 compared with a normal metal-deficient giant in the cluster (which has a metal deficiency of about 20). The enhanced abundances suggest that *s*-process elements, which must have been formed in the stellar interior, have been mixed to the surface during the star's evolution. Evidence is thus provided that an adequate supply of neutrons must have been made available during the star's previous evolution by a process different from that which occurs in more massive stars, which produce *s*-process elements after carbon burning.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

Dr. I. S. Glass in collaboration with Feast (Radcliffe Observatory) has extended his programme of infrared photometry of red giant stars in ω Cen.

A new series of photoelectric *UBV* observations of stars in ω Cen has been carried out by Miss E. A. Epps and Mr. T. G. Hawarden at the SAAO. This programme provides extensive coverage of standards over the field of the cluster for a new study of the RR Lyrae variables for which a series of *B* and *V* plates has been obtained by Dickens on the 72-inch Radcliffe telescope; the plates are currently being measured on GALAXY. Plate material on NGC 6362, a cluster of Oosterhoff Group I (ω Cen is Group II) has also been obtained by Dickens. The object of this programme is to make detailed and accurate comparisons of RR Lyrae variables in clusters of both groups in order to study the physical parameters responsible for the differences between the groups. The work on NGC 6362 is being done in collaboration with Coutts (David Dunlap Observatory) who is providing additional plate material.

The study of the RR Lyrae variables in the distant globular cluster IC 4499 by Dickens and Epps, in collaboration with Coutts, has been completed. The mean period of 28 *ab*-type variables is $0^d{\cdot}582 \pm 0^d{\cdot}012$, showing that although the cluster more closely resembles clusters of Oosterhoff Group I ($<P_{ab}> = 0^d{\cdot}55$) than those of Group II ($<P_{ab}> = 0^d{\cdot}65$), there appears to be a significant difference implying a closer resemblance to variables in some nearby dwarf spheroidal galaxies such as Leo II and Draco. One explanation of the differences in mean period implies a younger age for such dwarf spheroidals or clusters like IC 4499.

Variable Stars. Dr. D. H. P. Jones has extended his intermediate-band photometry of RR Lyraes to Cepheids of periods between 1 and 2 days using the 40-inch reflector at SAAO. Their metal abundances have been found to vary between a conventional Population I value and an extreme Population II value.

Dr. I. S. Glass has continued monitoring R Coronae Borealis stars at infrared wavelengths. It is hoped that it will be possible to correlate these measurements with optical photometry and spectroscopy carried out by Dr. P. J. Andrews and Feast (Radcliffe Observatory).

Glass has also surveyed Miras, late-type irregular variables and S, C, CS and SC stars at infrared wavelengths, mostly using the 18-inch SAAO telescope in Cape Town. The data are being used to investigate the systematics of colour-colour diagrams.

Dr. D. J. Stickland and Scarfe (University of Victoria, BC) have concluded a study of the orbit of the double-lined spectroscopic binary

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

α Equ. The components are found to be of approximately equal mass, a result which is in conflict with the mass ratio previously obtained by Deutsch.

Mr. B. Emerson has continued to collaborate with R. F. Griffin (Institute of Astronomy, Cambridge) on the determination of the orbital elements of spectroscopic binaries.

Star Formation and Interstellar Matter

Interstellar Extinction. Dr. I. S. Glass has carried out a programme of photoelectric photometry with van Breda and Whittet (University of St. Andrews) to examine possible variations in the interstellar extinction with wavelength.

Infrared Sources in Orion. In the wake of several critical papers by American astronomers, Dr. D. A. Allen and Dr. M. V. Penston have made a spirited defence of their model of Becklin's object in the Orion Nebula, which explains it as a very luminous star experiencing extremely high extinction ($\sim$100 magnitudes) by nebular dust.

Working with the infrared group at the California Institute of Technology, Penston (51) has discovered a new complex of infrared sources in Orion, which is associated with a molecular cloud producing intense CO emission.

Hydrogen-Emission Sky Survey. Dr. P. G. Murdin and Mr. A. P. Buckman (sandwich student) have constructed a prototype low-resolution night-sky photometer to discover faint emission regions. The fixed photometer may be set to a selected declination, and is then allowed to scan the sky all night unattended. Scans of the Orion area have included Hα and Hβ scans of the λ Ori H II region. Murdin has repeated these scans at two polarization angles with the 24-inch telescope at Siding Spring. It is hoped to construct a model of the gas and dust distribution in this classical Strömgren sphere.

Stellar Atmospheres, Structure and Evolution

Stellar Atmospheres and Abundance Studies. The reduction by Professor B. E. J. Pagel and Mrs. D. L. Harmer of the Mount Wilson plates of the "super-metal-rich" candidate μ Leo and standard stars continued; identifications of weak lines are being completed to improve the preliminary curve-of-growth analysis. The preliminary finding that μ Leo is less metal-rich than the Hyades (in agreement with other spectroscopic analyses, but in disagreement with narrow-band photometry interpreted by spectrum synthesis) has been confirmed, but it is not yet clear why the two methods have given different results.

The study by D. L. Harmer of metal-deficient stars discovered in the objective prism survey by Bond has revealed further stars with interest-

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

ing spectra for which accurate abundances can now be derived with the aid of the holographic grating developed at NPL.

The study by Pagel and Mr. B. E. Patchett of the statistics of metal abundance in G dwarfs was completed by incorporating data from the *Catalogue of Stars within 25 parsecs of the Sun* (*R. Obs. Annals* No. 5) and the Yale *Catalogue of Bright Stars*; the conclusions are similar to those previously reported. The data permit a mild upper limit to be placed on recent rates of inflow of intergalactic material and are in very good agreement with a prompt initial enrichment mechanism, proposed by Ostriker and Thuan, in which the gas of the galactic disk was enriched by the addition of 10 per cent of its mass in the form of secondary material from evolving stars in the halo, before the formation of disk stars.

Dr. D. J. Stickland's work on main-sequence star energy distributions has been extended to MK classes IV and III with the execution of a short observing programme on the Crossley telescope of the Lick Observatory. These photoelectric data are being supplemented by coudé observations on the 30-inch telescope.

Preliminary work has been completed by Stickland on the synthesis of spectra in the ultraviolet for comparison with the moderate (~2 Å) resolution observations from the S59 spectrometer of the TD1A satellite. It appears that the new lists of *f*-values produced by Kurucz are superior to the previously existing published data.

Mr J. B. Alexander has continued making photoelectric observations of the Swan bands of C_2 with the 36-inch telescope. An additional 60 stars have been observed during the year, including stars in the Hyades, Coma and Ursa Major clusters. Attention has been paid to finding metal-rich dwarfs in the general field.

Dr. I. S. Glass has carried out a short programme with the 60-inch infrared flux collector at Tenerife to determine *JHKL* colours of red dwarfs. The dwarfs are found to be distinguished from giants in the *J–H*/*H–K* two-colour diagram.

Mr. E. N. Walker is collaborating with van den Heuvel (University of Amsterdam) on the development of a novel process to explain the origin of Ap and Am stars.

Stellar Chromospheres. Dr. R. A. E. Fosbury and Mr. I. Cunliffe (vacation student) have used electronographic spectrograms of four dMe stars, obtained with the INT, to deduce the energy flux radiated in some chromospheric emission lines. When the stars are quiescent, these fluxes (averaged over the stellar surface) are about ten times the corresponding values in the Sun, and the Balmer-line source functions imply electron densities exceeding the solar ones by a similar or larger factor.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

These high fluxes and electron densities are not predicted by simple acoustic-wave heating models, but could be accounted for if there were a magnetic field of several kilogauss.

Emission-Line Objects and Planetary Nebulae. About 400 stellar emission-line objects, mostly Class I (stellar) planetary nebulae, have been examined at the infrared wavelengths 1·25 to 3·5 μm by Dr. D. A. Allen and Dr. I. S. Glass. Three distinct groups of objects have been found: (i) about 50 per cent were undetected; these are probably mostly genuine planetary nebulae or Be stars; (ii) almost 30 per cent have the continua of late-type stars, and are M, Me or symbiotic stars; (iii) the remaining 20 per cent exhibit infrared excesses attributable to circumstellar dust. Allen has begun a spectroscopic survey of all members of the last group and a few of the first two groups. Results so far published describe Henize 782 (3), a variable resembling the VV Cephei stars, and two southern emission galaxies and a planetary nebula previously misclassified as Be stars (2). Allen and Dr. B. L. Webster have identified a number of symbiotic stars with circumstellar dust: it was previously thought that dust cannot exist near these objects. A few objects of the third group have been detected by Allen as weak radio sources at 2·8 cm. The radio emission is that of Bremsstrahlung, intermediate between the optically thin and thick cases.

Webster has been comparing the properties of planetary nebulae in the Magellanic clouds and the galactic bulge. The oxygen abundance in these objects is similar in the two clouds, and slightly lower than in the galactic bulge.

Thackeray (Radcliffe Observatory) and Webster have detected broad emission lines from the hot remnant of the nova outburst of RR Telescopii. This remnant appears to contract and increase in temperature from about 30000 K to more than 100000 K over a period of 10 years.

Eta Carinae. Observations by the Leicester University group using *Copernicus* showed that η Car could not be the soft X-ray source at similar galactic longitude tentatively identified with it on the basis of a Livermore rocket measurement in 1972. Professor B. E. J. Pagel, together with Griffiths and Peacock (University of Leicester) showed that this negative result is entirely consistent with the thermal model of the emission and with an earlier failure to detect the green coronal line (48).

Infrared Photometry of Standard Stars. Dr. I. S. Glass has continued his programme of observations intended to improve the southern infrared standard system. A first report has been published (20).

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

Galactic Astronomy

Kinematics and Photometry in Selected Areas. Considerable progress has been made by Mr. K. Muanwong (research student) in the measurement on GALAXY and reduction of plates on Selected Areas 51, 54, 57, 71, 82, 94, 107. In all, 79 astrometric plates have each been measured in two orientations, to eliminate magnitude equation, and 42 photometric plates have each been measured in one orientation.

In order to determine proper motions of faint M dwarfs in the general field, Mr. C. A. Murray has started the measurement of deep plates, borrowed from Hale Observatories, on 12 Selected Areas at various galactic latitudes.

Dr. D. H. P. Jones and Mr. A. J. Penny have initiated a programme to set up photometric zero points on Kron's *R,I* System in the equatorial Selected Areas and also SA 141 (South Galactic Cap), using the SAAO 20-inch reflector.

Solar Neighbourhood. Mrs. J. E. Sinclair and Dr. D. H. P. Jones have continued their 4-colour narrow-band photometry of faint red stars which distinguishes M dwarfs by their high CaH:TiO ratio. They have used the INT and 36-inch reflectors at RGO and the 40-inch reflector at SAAO to study both galactic caps and the field of the Pleiades. In the Pleiades field, cluster dwarfs can be distinguished from field dwarfs by the fine astrometric and photometric studies already available in the literature. So far this project has revealed very few undiscovered red dwarfs. Up to a point this is to be expected, for a search complete to a given *I*-magnitude sweeps out roughly 3000 times the volume of space at dM0 as it does at dM6.

The photometric parallaxes measured in the above programme are complemented by the continuing trigonometric parallax programme on the 26-inch telescope, under the supervision of Mr. J. B. Alexander and Mr. B. G. F. Scales. During the year the plates for 13 fields have been completely measured and are now being reduced; five new parallaxes have been determined.

Observations for the INT parallax programme have continued and should be completed in 1975.

Solar System

Transits of Mercury. Mr. L. V. Morrison and Mr. C. G. Ward (sandwich student) have made an analysis of about 2500 observations of the transits of Mercury in the period 1677 to 1973 in order to improve the elements of Mercury's orbit and to provide estimates of the differences between universal time and ephemeris time for comparison with those obtained from observations of the Moon. The provisional

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

results for the motion of the perihelion of Mercury's orbit and the tidal contribution to the orbital acceleration of the Moon appear to be of considerable value and interest.

Planetary Satellites. Dr. A. T. Sinclair has continued his work on the improvement of the orbits of the satellites of Saturn, using observations made with the 13-inch and 26-inch telescopes. He has also studied the libration amongst the Galilean satellites of Jupiter, and concluded that it is unlikely that it is the result of orbital evolution caused by tidal forces.

4 NATIONAL AND INTERNATIONAL SERVICES

Time and Latitude Service

Photographic Zenith Tube. Under the supervision of Mr. N. P. J. O'Hora, 2688 star transits were observed with the PZT on 146 nights, and the time and latitude results communicated weekly to the Bureau International de l'Heure (BIH) and the office of the International Polar Motion Service. An improved catalogue of positions and proper motions has been derived by O'Hora, Mr. J. V. Carey and Wheeler (Calgary PZT Observatory) from an analysis of the PZT observations made at Herstmonceux in 1958–1972 and at Calgary in the years 1968–1972. All observations to date are being re-reduced using the new stellar data and improved reduction techniques.

The design and manufacture of components required for modification of the PZT to enable it to operate completely under automatic control have continued. Preliminary work on the use of a mini-computer for the on-line monitoring and recording of plate-measuring has also been carried out.

Danjon Astrolabe. The modifications to the instrument, associated with the replacement of the original objective prism by a reflecting prism made of Cer-Vit, have been completed. Tests of the new configuration have been delayed by the shortage of scientific staff.

Rotation of the Earth. The comparison between universal time (UT1) and atomic time shows that the average rate of rotation of the Earth remained constant during the year, so that the departure between the two scales remained at the value of 2·7 ms d^{-1}, to which it changed over quite a short interval in 1973 October. This change is the first long-term *increase* in the rate of rotation since monitoring of the Earth's rotation against atomic time began in 1955.

Atomic Time. Under the supervision of Miss C. J. A. Penny, the Greenwich atomic time-scale (GA2) was formed throughout the year by combining the scales of individual caesium-beam time standards

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

(atomic clocks) at RGO. The results of the comparisons of the individual clocks with the time pulses of the radio signals of the Loran-C navigation system were communicated to the BIH for use in the formation of the international atomic time scale TAI.

The atomic clocks purchased since the beginning of 1972 have not proved to be as reliable as earlier clocks. Thus GA2 was based on five clocks for less than one month; for $2\frac{1}{2}$ months the scale was based on only two clocks, one of which has been in operation since 1967. In spite of these difficulties, the aim of providing a uniform, independent time-scale has been realized, as is shown by the comparisons with TAI, which is currently based on the mean of some 70 clocks, but which is published about two months in arrears. The frequency of GA2 was about 3 parts in 10^{13} lower than that of TAI in 1974, whereas it was about 5 parts in 10^{13} lower in 1973.

The frequency of TAI has been compared with the frequencies of primary laboratory standards in other countries. It appears that the difference was almost constant throughout 1974, but the frequency of TAI was about 1 part in 10^{12} high.

Staff of the US Naval Observatory made one visit with a portable atomic clock in order to establish more precisely the difference between the clocks at Herstmonceux and elsewhere and to investigate the causes of the small discrepancies between the time-differences derived from intercomparisons via the Loran-C signals and those via a portable clock.

A new battery system and a new frequency distribution system, designed by Mr. H. G. Gill, were both installed during the year.

Radio Time Signals. The fiftieth anniversary of the inception of the "six-pips" time signals occurred on 1974 February 5. During the year the time signals, on the scale of coordinated universal time (UTC), were provided to the BBC by land-line without interruption. Throughout 1974 the difference TAI–UTC was 13 seconds, but by international agreement a positive leap second was inserted in UTC as the last second of December 31.

The national radio time signals emitted by the Post Office from Rugby (GBR) have been monitored at Herstmonceux, and the reserve transmissions (GBZ) were calibrated for use in early April. Other international time signals have also been monitored regularly.

HM Nautical Almanac Office Publications and Data Services

Almanacs and Ephemerides. The work of preparation and publication of almanacs and ephemerides has continued under the supervision of Dr. B. D. Yallop. *Advanced Data for the Astronomical Ephemeris 1979*

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

was distributed on a limited basis; the list of publications issued is contained in Section 7. Owing to an industrial dispute at HM Stationery Office and a paper shortage, the scheduled reprint of the *Explanatory Supplement to the Astronomical Ephemeris* has not yet appeared.

It has been agreed that *The Air Almanac* shall be published in two parts each year, instead of three, as from the editions for 1977. The detailed preparatory work is progressing well. Provisional agreement was reached with the Nautical Almanac Office of the US Naval Observatory on changes in the publication arrangements and contents of *The Astronomical Ephemeris* for 1981 onwards (77). Complete unification with *The American Ephemeris*, greater cooperation with other ephemeris offices, and more economical arrangements for the early publication of data for use in preparing local almanacs and for planning purposes are envisaged. Changes in layout and content will be made in 1981, but the basis of the principal ephemerides will remain unchanged until the edition for 1984, since this is the earliest year in which it will be possible for the Astronomisches Rechen-Institut, at Heidelberg, to publish apparent places of stars based on a new fundamental catalogue (FK5).

Preliminary work has been carried out on proposals for the improvement of *The Star Almanac* by providing star charts, or a separate star atlas, and sets of coefficients for the calculation of the daily data using small programmable electronic calculators.

Astronomical Data Services. Topocentric astronomical data for 1975 for 31 observatories were prepared and distributed. Lists of stellar data with positions for equinox 1975·5 were prepared and distributed on a limited basis (16); these lists are intended to supplement the list of mean places in the *Astronomical Ephemeris*. Transit ephemerides for the Moon and planets for 1975 were prepared for Herstmonceux. Diagrams showing the daylight and moonlight conditions for each month have been prepared as usual for navigational purposes and have also been distributed for use by astronomers.

Copies of ephemerides and star catalogues on magnetic tape were also supplied as requested.

Astronomical data for civil purposes were supplied to newspapers, diary publishers, solicitors, and many other organisations and individuals. The improved computing facilities provided by the ICL 1903T system have proved to be useful for much of this type of work. Mr. S. T. Devereux (sandwich student) developed an experimental question-and-answer system.

Dr. B. D. Yallop, with the assistance of Miss A. Maxwell (vacation student), has studied the variations of night-sky brightness due to the

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

combined effects of moonlight and twilight in order to derive an empirical formula which can be used in the planning of observing programmes.

Occultations. The regular programme for the prediction and reduction of occultations of stars by the Moon has continued under the direction of Mr. L. V. Morrison. Worldwide predictions were distributed to observatories and individual observers and for publication (62). During the year about 7000 timings were received, coded and reduced. The preparation of a reproducible listing of all occultation observations received since 1943 has been continued. The collection, coding and reduction of observations made before 1943 continued in preparation for a new analysis to improve the constants of the lunar theory and the determination of the past variations in the rotation of the Earth. Predictions of occultations of radio sources by the Moon were made and distributed, and searches for occultations of stars by planets and satellites were extended (60, 63).

Lunar Laser Ranging. Dr. G. A. Wilkins and Dr. A. T. Sinclair have taken part in the formulation of a proposal for SRC collaboration with an Australian group which is now installing equipment for lunar laser ranging. Under this proposal, the RGO would become the UK data centre for distribution of lunar laser ranging data to interested astronomers and geophysicists.

Stellar Reference Frame and Related Observations

Cooke Transit Circle. Observations of the Sun, Moon (limbs and Mösting A), planets and clock and azimuth stars have continued with the Cooke Transit Circle at Herstmonceux, under the direction of Mr. R. H. Tucker. Considerable progress has been made in setting up the fundamental right ascension and declination system from the observations made since 1957. This work forms part of the programme for the compilation of the fundamental star catalogue FK5, now under way at the Astronomisches Rechen-Institut, Heidelberg.

The programme of observations of zodiacal stars has been augmented by 411 stars at the extreme limit of the zodiacal belt. This programme is 84 per cent complete; the contribution to the international programme of observations of northern PZT stars is 81 per cent complete.

The National Engineering Laboratory, East Kilbride, has made good progress in the development and construction of an automatic digital circle-reading system to replace the present circle and cameras of the Cooke TC.

Catalogues in Preparation. The occasional observations of the Moon's limb and Mösting A made with the Cooke TC between 1958 and 1971

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

have been prepared for publication. Observations of the Sun, Moon and planets for 1972–73 are also being prepared for publication. Work is proceeding on the *Third Greenwich Catalogue for 1950*, which will contain the last series of observations made with the Airy Transit Circle at Greenwich from 1942 to 1954. Mr. K. C. Blackwell is supervising this work.

Southern Hemisphere Reference Frame. Observations for the Cape contribution to the international Southern Reference Star (SRS) programme continued, under the direction of Mr. A. Shortland, until 1974 April 25. The bulk of the programme had by then been completed. The Gill Transit Circle has now been retired after more than 70 years' service, during which time it carried almost unaided the burden of position determinations of bright stars in the southern sky. Reduction of the Cape SRS observations has continued at Herstmonceux.

Cape Photographic Survey. This programme, which consists of a four-fold overlapping coverage of the southern hemisphere on plates taken with the wide-angle astrometric camera at SAAO, is designed to provide positions of stars in the southern hemisphere for epoch around 1970. This will form the southern counterpart of AGK3. The positions will be referred to the fundamental system by means of the international observations being made for the SRS programme. Virtually all the 6000 plates for this survey have now been received at RGO for measurement on GALAXY.

Solar Activity Service

Observations of Solar Activity. Under the supervision of Mr. P. S. Laurie, and latterly of Dr. A. L. T. Powell, the Sun was photographed at Herstmonceux in white light on 285 days, and in Hα light with the Lyot filter on 195 days. With the continued cooperation of the SAAO, white-light photoheliograms for transmission to RGO were also obtained on 227 days at Cape Town. The series of daily photographs of the Sun in white light was begun at Greenwich on 1874 April 17. Thus a unique record covering more than 100 years and 9 cycles of solar activity has now been obtained. Continuous monitoring of radio reception has been maintained throughout 1974 at 25·5 kHz and 6·090 MHz, for detection of sudden enhancements of atmospherics and sudden ionospheric disturbances, respectively. Current information on solar activity has continued to be distributed widely by monthly Solar Activity Circulars. Immediate information of significant solar events has also been supplied to interested organizations.

Solar activity declined steadily during 1974. The first high-latitude sunspot of the next solar cycle was observed on 1974 November 15, indicating that minimum activity is likely to occur towards the end of 1975.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

Photoheliographic Results. The publication of a detailed daily record of the positions and areas of sunspots and faculae and of the morphology of individual sunspot groups also commenced in 1874. With the cooperation of other observatories (notably at Cape Town and Kodaikanal, India), who supply plates as required, a continuous and homogeneous daily record has been assembled, with only occasional breaks in the early years. Some progress was made during the year in reducing the backlog of plate measuring, data processing and preparation of results for publication. *Photoheliographic Results* for the years up to and including 1965 have now been published, and those for 1966 are in an advanced state of preparation.

RGO Archives

The RGO Archives are scheduled under the Public Record Act 1958 as documents of national importance, and are administered under the Act. The Archives Room is a repository of the Public Record Office and inspected annually. History of science researchers are permitted to examine the manuscripts by appointment. Twelve such historians were assisted during the year by the Archivist, Mr. P. S. Laurie. Approximately 100 enquiries by correspondence were dealt with and copies of material supplied when possible on a reciprocal exchange or prepayment basis.

The papers of the first four Astronomers Royal and the Board of Longitude have already been microfilmed, and the recent provision of a recorder/printer should much improve facilities. However, a very substantial amount of material has still to be catalogued and microfilmed.

5 INTERNAL SERVICES

Central Computer Services

Mr. A. E. Carter continues to be responsible for the central computer service. The ICL 1909 central processor was taken out of service at the beginning of January and was replaced by an ICL 1903T central processor with 96K words of semi-conductor store. Two exchangeable-disk drives (2M words each) were added. The new system came into use at the beginning of February. The extra storage capacity has made it possible to use the GEORGE 3 Operating System since the end of March. Mr. J. V. Carey has been responsible for the implementation and development of the operating system. Two 9-track magnetic-tape transports and five alpha-numeric visual-display units, for remote-access work, have been added to the system during the year; some surplus multiplexing and data-terminal equipment was obtained from the Appleton Laboratory. A fourth tele-typewriter and a small graphics display unit have been ordered.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

The computer system continued to be operated for two shifts on normal working days, under the general management of Mrs. D. E. Hobden. The average amount of useful time (*i.e.* excluding time lost for faults and hardware maintenance) was 271 hours a month. Of this useful time: 21 per cent was devoted to the provision of national facilities (mainly accounted for by GALAXY system development and initial data processing); 22 per cent was devoted to the provision of national and international services; 33 per cent was accounted for by astronomical research (the major part being analysis of plate material obtained using GALAXY); 13 per cent was used (and paid for) by the Geomagnetism Unit of the Natural Environment Research Council based at Herstmonceux; and 11 per cent for systems and software maintenance and development. The average serviceability ratio was 0·97.

The remote job-entry work-station link to the ICL 1906A computer at the Atlas Computer Laboratory has been used only to a limited extent during the year, but a considerable increase in its work load is expected.

A programming advisory and punching service has continued to be provided for all users of the central computer.

An interactive graphics capability is being developed by Dr. J. S. Beale. It is hoped that the system will be suitable for many applications including: computer simulation of the mechanical properties of large structures and of telescope drives; interactive optical design; the analysis of spectra; pulsar and binary star periodic analysis.

Engineering Services

The Engineering and Electronics Departments, managed respectively by Mr. P. F. Cottrell and Mr. H. G. Gill, are responsible for the maintenance of all the telescopes, measuring machines, and electronic equipment of the Observatory. During the year the Engineering Department carried out 72 major instrument changes on the INT and 36 changes on the 36-inch reflector. The time spent on manufacturing projects was divided approximately as follows: instruments for AAT and SAAO, 34 per cent; work on telescopes at RGO, including the INT, 42 per cent; minor projects, 24 per cent.

Libraries

The RGO Library, supervised by Miss J. E. Perry, now contains over 20000 volumes covering most branches of astronomy and many other subjects of relevance to the work of the Observatory. Subscriptions are current for 137 journals, and material is exchanged with observatories and institutions in all parts of the world; 126 text books were purchased during the year.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

The separate and smaller library of HM Nautical Almanac Office contains more specialized material, but has been expanded in recent years to cover a wider range of current astronomical text books and journals. Dr. G. A. Wilkins, who supervises the NAO Library, has continued to assist in the revision of the Universal Decimal Classification scheme for astronomy (UDC 52).

6 GENERAL

Visitors

The Isaac Newton Telescope was used by 17 groups of visiting observers, five more than last year. The Large Telescope Users' Panel allocated 216 nights for these programmes; 135 nights were allocated to RGO observers.

The 36-inch telescope was used by groups from the University of Glasgow, led by Dr. D. Clarke, and from the University of Durham, led by Dr. S. M. Scarrott. Dr. A. D. Andrews (Armagh Observatory), Mr. R. W. Forrest (Hatfield Polytechnic Observatory), Mr. H. Netzer (University of Sussex research student) and several vacation students also used the telescope. Members of RGO staff either assisted or collaborated with the visiting observers in each case.

The 30-inch coudé telescope was used by Dr. A. Boksenberg (University College, London), Mr. M. G. Edmunds and Dr. P. M. Williams (Institute of Astronomy, Cambridge), and Mr. T. G. R. Beynon (University of Sussex research student), in collaboration with RGO staff.

Mr. D. R. L. Jones (Glamorgan Polytechnic) used the 26-inch telescope to make observations of Comet Kohoutek.

Professor W. H. McCrea spent a considerable portion of the year at the RGO working on a short history of the Observatory to be published on the occasion of the RGO Tercentenary in 1975.

Other visitors included:

Mr. H. V. Linardi, Naval Observatory, Buenos Aires, who spent three months at the Observatory in connection with his work on the electronic instrumentation of the Argentine Time Service;

Mr. B. B. Jezieniecke and Mr. C. A. Mondinalli, Astronomical Observatory of the University, La Plata, who spent three months in the Time Department working on problems connected with the determination of UT and latitude variation;

Dr. R. Florentin-Nielsen, Copenhagen University Observatory, who is spending six months in the Physics Department working on the development and testing of electronographic image tubes;

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

Sir Richard Woolley, Director of the South African Astronomical Observatory.

The following also paid short visits to the RGO during the year:

Dr. P. R. Brand, Astronomy Department, University of Edinburgh;

Dr. D. Crampton and Dr. E. H. Richardson, Dominion Astrophysical Observatory, Victoria, B.C., and Professor W. Wehlau, University of Western Ontario;

Sir Hugh and Lady Ennor, Australian Secretary of State for Science;

Dr. K. C. Freeman, Mount Stromlo and Siding Spring Observatories;

Dr. J. Jung, Director of the Stellar Data Centre at the Strasbourg Observatory;

Professor E. J. Wampler, Director Designate of the Anglo-Australian Telescope;

Professor P. A. Wayman, Director of Dunsink Observatory;

Dr. P. Wehinger, Wise Observatory, Israel.

In addition, parties from the New South Wales Institute of Surveyors, the International Union of Pure and Applied Chemistry, the Northern Industrial Corporation of Peking, and members of the Navigation Courses organized by HMS *Dryad*, have visited the RGO.

Students

Five graduate students of the University of Sussex have worked regularly at the RGO during the year: Mr. T. G. R. Beynon, Mr. C. Moss, Mr. K. Muanwong, Mr. H. Netzer and Mr. M. J. Ward. Other students from the University of Sussex continue to make use of the facilities of the RGO, where these are appropriate to their studies.

Five sandwich students have also worked at the RGO for extended periods during the year: Mr. C. S. Buck (University of Surrey), Mr. A. P. Buckman (Bath University of Technology), Mr. S. Devereux (Hatfield Polytechnic Observatory), Mr. J. J. Redfearn (Brunel University) and Mr. C. G. Ward (Bath University of Technology).

As in previous years, an eight-week course in astronomy was held in the long vacation and was attended by 11 students from various British Universities and one from the USA.

Staff Matters

Professor F. Graham Smith joined the staff on October 1 in the grade of Deputy Chief Scientific Officer with the title Director Designate. He will succeed Dr. A. Hunter, who is due to retire at the end of 1975.

Mr. R. Gordon, Principal, joined the staff as Head of Administration on February 4.

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1975QJRAS..16..444H

Dr. P. G. Murdin, Dr. M. V. Penston and Dr. B. L. Webster have been promoted to Principal Scientific Officer.

Mr. D. R. Palmer, Principal Scientific Officer, retired in May due to ill health.

Mr. P. S. Laurie, Senior Scientific Officer, who has been head of the Solar Department since 1957, transferred to full-time duty as Archivist on October 1.

Dr. A. L. T. Powell, Senior Scientific Officer, succeeded Mr. Laurie as head of the Solar Department on October 1.

Dr. A. Hunter has succeeded Professor E. M. Burbidge on the Advisory Committee of the South African Astronomical Observatory, and has continued to serve as Treasurer of the Royal Astronomical Society.

Professor B. E. J. Pagel is a Visiting Professor at the University of Sussex, and has continued to serve as Vice-President and Foreign Correspondent of the Royal Astronomical Society. He was also one of the organizers of the NATO course on "The Origin and Distribution of the Elements" held at the Institute of Astronomy, Cambridge, from July 22 to August 9.

Mr. C. A. Murray has continued to serve on the Council of the Centre de Données Stellaires (CDS), and attended the annual meeting of the Council at Haute Provence in April. He is a Visiting Lecturer at the University of Sussex, and has been elected to the Council of the Royal Astronomical Society.

Mr. C. A. Murray and Dr. G. A. Wilkins attended a working meeting on astronomical constants and ephemerides, arranged by the President of IAU Commission 4, at the US Naval Observatory, Washington, in September/October.

Dr. G. A. Wilkins attended the meeting of the Council of the Federation of Astronomical and Geophysical Services, as a delegate of the IAU, in Paris in May; he was appointed Secretary from the beginning of 1975. He also attended the CODATA Conference and the XI General Assembly of CODATA, as IAU delegate, at Erevan, Armenia, in June, and has been appointed Chairman of an Advisory Panel on the Geosciences.

Mr. H. M. Smith continued to act as Chairman of the Directing Board of the Bureau International de l'Heure and to participate in the activities of the Comité Consultatif pour la Définition de la Seconde (CCDS) which recommended in July that the UTC time-scale should be used as the basis for official times in all countries. He also attended the XIII plenary assembly of the International Radio Consultative Committee (CCIR) in Geneva in March as IAU representative and as

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System