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ROYAL GREENWICH OBSERVATORY

(*Director, Sir Richard Woolley, O.B.E., F.R.S., Astronomer Royal*)

and

ROYAL OBSERVATORY, CAPE OF GOOD HOPE

(*Officer-in-Charge, G.A.Harding*)

(Report for the year ending 1970 December 31)

STELLAR KINEMATICS

Nearby stars

The extended catalogue of nearby stars has been published as *Royal Observatory Annal, No. 5* (*62*). An analysis of the properties of the stars is in an advanced state of preparation.

Radial velocities

The observations of G stars in one of four areas, have been reduced completely, and the results support the idea of perturbations by large concentrations of matter in the galactic disc (see *Q. Jl R. astr. Soc.*, **11**, 236) previously deduced from observations of K stars. Work on the three remaining areas is nearing completion.

A search for spectroscopic binaries among a certain class of stars is in progress, using spectra at 8Å mm^{-1} taken with the I.N.T.

Spectra of some of the Hyades were obtained at 25Å mm^{-1} for the study of radial velocities in the cluster.

Measurements have been made of radial velocities of stars in one of Schmidt-Kaler's 'rings'.

Proper motions

The conventional model of secular parallaxes and solar apex which has been used for reducing relative proper motions to an absolute system has been investigated, and evidence has been found that secular parallaxes in high latitudes have previously been underestimated. This has an important effect on the statistical parallaxes of high latitude objects **(40)**.

A new method for deriving statistical parallaxes has been developed and applied to RR Lyrae stars; the resulting absolute magnitude appears to be fainter than that currently supposed.

The apparent rotation of the stellar system due to precession and galactic rotation has been investigated using a new technique which is independent of the proper motion distribution.

The programme of repetition of the Radcliffe proper motion plates of the Kapteyn selected areas is 85 per cent complete; 18 plates on SA 54 have been measured on GALAXY at the Royal Observatory, Edinburgh.

Analysis, including new determinations of proper motions of 112 semi-regular and RV Tauri variables for statistical absolute magnitude, is in progress.

The production of the voluminous tables of systematic catalogue corrections in computer-readable form has been pressed forward. The availability of direct-access disc storage has considerably simplified the process of retrieving this information in the required order.

TRIGONOMETRIC PARALLAXES

Herstmonceux

By the end of the year nearly half of the 110 stars on the programme had accumulated a weight of at least 20 (estimated s.e. of parallax 0″·007). Preliminary parallaxes for 10 stars have been derived with an average s.e. of 0″·007 which is considerably better than that achieved at Greenwich. The average of these parallaxes is significantly lower than that derived for these stars from the data in Gliese's catalogue.

Gaps in the observing programme are being filled by the phasing-in of 90 additional stars. Most of these are stars in Gliese's catalogue, or the Herstmonceux extension, for which a definitive trigonometric parallax is required. Among the remainder are seven fields containing 16 of the Hyades stars recommended by Van Altena for intensive international investigations, six red giants with anomalous K-line luminosities, and 12 stars from earlier Greenwich parallax programmes which merit further observation.

Cape

At the Cape, 833 plates were taken during the year for parallax measurements and 38 for the better determination of the proper motions of certain parallax stars. Routine measurement of over 3000 plates now available has started. The parallaxes of two suspected white dwarfs, LB 3303 and LB 3459, were determined. The former is almost certainly a white dwarf; the latter is not.

STAR CLUSTERS

A new colour–magnitude array and two-colour diagram have been prepared for the cluster NGC 6171, based on observations with the Mt Wilson telescopes.

Photometric plates on a region of the LMC containing Bok's cluster have been borrowed from Dunsink Observatory and are awaiting measurement on GALAXY at the Royal Observatory, Edinburgh.

At the Cape the search for old southern open clusters has continued. Melotte 66, NGC 2204, 2243, 3960 and 6259, IC 2714 and Trumpler 5 are being studied. Of these, only NGC 6259 appears to be younger than the Hyades. A photoelectric sequence for Melotte 66, extending to $V = 17{\cdot}6$, was obtained using the 40-inch Elizabeth Telescope at the Cape and the 74-inch Radcliffe reflector in Pretoria, and a start has been made with one for NGC 2204, which it is hoped to extend to the main sequence when the 40-inch has been moved to Sutherland. Photographic photometry is also planned. NGC 2243 seems to be unusually far from the galactic plane.

Second epoch plates of southern open clusters, for which first epoch plates were obtained in the late 1930s, are being secured on the McClean refractor.

VARIABLE STARS

Herstmonceux

Trials of the Baade–Wesselink method of finding the radius of pulsating variables have been made. In this connection a velocity curve was obtained for the variable V363 Cas, using the I.N.T. A search for comparisons to pulsating variables has been made, with a view to using the comparisons to indicate distance moduli.

A paper on the temperatures and gravities of δ Scuti type variables is in an advanced stage of preparation.

The semi-regular c type variables with the relatively stable periods in the I Persei association are found to obey a period–luminosity relationship.

Cape

Photoelectric observations of variable stars are being continued at the Cape. Light curves have been obtained for the cepheid variable κ Pavonis and the eclipsing binaries HD 86118 (= BV470, $P = 4{\cdot}4780$ d) and DV Aqr. θ Tuc was found to be a small-range variable with a period of about 75 min.

A search has been made for new flare stars amongst dwarf M emission line stars. Gliese 803 (HD 197481) and Gliese 234 (probably) appear to be UV Ceti type stars **(18)**.

Visual observations of long-period variables are being continued with the 6-inch refractor at the Cape. Some of the sequences have been re-measured photoelectrically **(23)**.

STELLAR ATMOSPHERES AND ABUNDANCE STUDIES

The work of H.Spinrad and B.J.Taylor, who have identified what they consider to be 'super metal-rich' (SMR) old galactic clusters and

field stars by narrow-band photometry of strong spectral features has given rise to a good deal of controversy as to the accuracy and significance of their results. Some curve-of-growth and model-atmosphere analyses of stars which they find to be SMR (i.e. more metal-rich than the Hyades), or which they would find to be SMR if their method were applied to them, suggest that their method may be incorrect owing to unusual microturbulence, blanketing or other causes. However, a new differential analysis of one such star, δ Pavonis, on the basis of Mount Stromlo coudé spectra secured by Pagel in 1963 suggests that it is indeed slightly SMR in good agreement with the conclusion that would presumably have been reached by the Spinrad–Taylor method if it had been applied **(31)**; and their results on another dwarf star, HR 72, have been confirmed by a differential model-atmosphere analysis. The importance of these results lies less in the existence of a few SMR stars more or less in the solar neighbourhood than in a check on the narrow-band technique, which is producing suggestive results on high heavy-element abundances in the nuclear regions of large galaxies.

A systematic study by D.R.Fawell (now at University of London Observatory) of the application of model atmospheres to molecular lines of CH, CN, NH and CO in G and K stars leads to the following conclusions. (1) The coolest extremely metal-deficient red giants (Barnard 121–13 in M92 and HDE 232078) have an over-deficiency of carbon compared to iron if unblanketed radiative or scaled solar models are applicable to them, whereas in hotter halo stars (e.g. HD 122563) any change in C/Fe is marginal, in agreement with conclusions reached by Miss J.G.Cohen. (2) Both the mildly metal-deficient systems γ Leo AB and α Boo have enhanced O/C compared to the Sun, but in γ Leo AB oxygen is slightly reduced, as are the metals, whereas in α Boo oxygen does not share the deficiency shown about equally by carbon and metals. (3) Both ^{13}C and N are enhanced in α Boo, in accordance with predictions by Iben for somewhat more massive stars of Population I composition, with $^{12}C/^{13} \approx 10$ from both CN near λ 8000 Å and CO near $2{\cdot}3\mu$. The lower $^{12}C/^{13}C$ ratio found from CO by T.F.Greene seems to result from inadequate allowance for curve-of-growth effects. New oscillator strengths have been found for the red CN and ultra-violet NH systems and variations in bond intensity have been predicted for an extensive grid of both radiative and scaled solar models **(27)**. The overdeficiency of nitrogen found previously in ν Indi **(30)** has now been confirmed and, indeed, increased by a spectral-synthesis investigation of the ultra-violet CN region **(6)**. Other metal-deficient stars are being examined at both high and low dispersions to determine whether they also show the effect.

In a study of the compositions of double-lined metallic-line A-type spectroscopic binaries, D.J.Stickland has developed a new method of determining the effective temperature from relative line intensities of Fe, Fe^+ and Ti^+, calibrated against stars of known temperature. The resulting continuum energy distributions predicted for the combined systems are in good agreement with the observations.

A study by R.A.E.Fosbury of the Hα profile in F–K stars, using coudé material from the Herstmonceux 30-inch telescope and elsewhere, suggests that the central depth is correlated with H and K emission strength in the sense that the line tends to be filled in by an active chromosphere. A relationship with metal abundance may also exist.

Dr D.R.Branch, currently at Herstmonceux after working at the California Institute of Technology, has identified absorption lines of He I and Ne I blue-shifted by 4000–8000 km s^{-1} in the spectrum of the Type I supernova of 1954 in NGC 4214 previously studied by McLaughlin. The identification of He I absorption agrees with McLaughlin's conclusions that there is a true background continuum probably heavily reddened. McLaughlin's suggestion of broad emission bands seems to have been occasioned by the properties of the colour filter used for the exposure in the visual region. The 'Type V' supernova of 1961 in NGC 1058 has been studied by Branch and Greenstein by a spectrum synthesis technique. Red shifts of emission lines were caused by strong violet-shifted absorption components. No significant abundance peculiarities among the metals scandium through nickel were detected.

EXTRA-GALACTIC STUDIES

A study of radial velocity dispersions in clusters of galaxies has been made.

A statistical analysis of Wood's 12-colour photometry of galaxies has been published (see also *Q. Jl R. astr. Soc.*, **11**, 241).

Observations of bright quasars, N-galaxies and Seyfert galaxies were continued and these showed that the character of the light variations was similar for all three classes of object. An intensive programme of observation of BL Lac showed it to be more rapidly variable than the extra-galactic objects. It lies near the edge of a nearby cluster of galaxies of about the same magnitude and this cluster contains another very compact object noted by Zwicky. However, the galactic latitude $b = -10°$ is consistent with BL Lac lying within the galaxy. It may be a good candidate to be a 'Black Hole'.

Positions

A new programme of optical positions of 41 radio sources has been started, using I.N.T. and 26-inch plates. At least two plates have been

obtained of nine sources. The reference system for reduction will be AGK3 which has been received on magnetic tapes from Hamburg Observatory.

Plates have been obtained on the McClean refractor at the Cape to assist in the identification of radio sources which are being observed in Pretoria.

PHOTOELECTRIC PHOTOMETRY

Sierra Nevada

Observations have been continued along the same lines as last year. Particular emphasis has been given to stars in the extended catalogue of nearby stars, and to establishing local standards in Selected Areas and the fields of quasars. The observatory was successfully maintained in spite of the distance problem, and was also used by visitors from other observatories.

Cape

The 40-in Elizabeth Telescope has again been used exclusively for photoelectric photometry. *UBV* observations of stars in the original Gliese catalogue and in the RGO extension to 25 parsecs were continued as the principal observing programme. Subsidiary programmes include some stars in the Radcliffe radial velocity programme and some weak-lined stars. J.B.Alexander continued with his programme of *u v b y* (Strömgren system) photometry until he returned to Herstmonceux in May.

D.Crampton (DAO, Victoria) used the telescope on 9 nights to carry out *UBV* photometry of early-type stars suspected to be sources of illumination for H II regions, and D.Kilkenny (St Andrews University Observatory) used it on 16 nights for *UBV* and Hβ observations, continuing and extending the photometry of early-type stars at intermediate galactic latitudes carried out by van Breda and Hill in previous years.

The photometry of bright stars with the Astrographic refractor has been completed. Three-colour photometry is now available for almost all the stars in the *Yale Bright Star Catalogue* south of + 10° declination and a list is ready for publication. The observations of circumpolar stars are being analysed.

The observations of early-type stars being made with the 24-inch Victoria Telescope have been completed and published **(20)**.

The 18-inch (49 cm) reflector has been used for observing variable stars and for establishing or checking zero points. This has been done for stars in the LMC **(19)** and in Harvard Standard Region F 1, and

further work on zero points and colour equations is in progress in the E and F regions and elsewhere.

POSITIONAL ASTRONOMY

Meridian observations, Herstmonceux

The Sun and planets continue to be observed regularly, The Herstmonceux R.A. observations are being investigated for evidence of differences between observers, and for day-*minus*-night differences.

The preliminary checking of transit observations for acceptability is now carried out on the computer, which simultaneously records the progress towards completing the required number of observations. New graticules, carrying two interrupted parallel lines, have been installed in the circle cameras; the previous graticules had three complete parallel lines.

Cape

Progress continues with the transfer of the Cape T.C. reductions to the Herstmonceux computer. A fresh working list for Cape Bright Star observations was prepared.

About one-quarter of the observations needed to complete the $-52°$ to $-64°$ zone of the southern reference star (SRS) programme had been obtained by the end of the year. The concurrent bright star programme (3rd Cape Fundamental Catalogue for 1950) was 58 per cent complete.

Photographic star positions

The first thousand plates on the current Cape astrometric camera programme (zone $-40°$ to $-52°$) have been received at Herstmonceux for measurement on GALAXY, search co-ordinates for all stars to be measured are being derived by surveying a projection of each plate with a D-mac pencil follower.

Lunar occultations

Twenty-three observations of occultations were obtained at the Cape, seven of these photoelectrically. A grazing occultation of Antares was observed from near Touwsrivier, thirty events being timed from seven sites **(28)**.

Artificial satellites

During the year 826 satellite passes were tracked with the kine-theodolite at the Cape.

TIME AND LATITUDE SERVICE

The results for the year are based on 1998 transit observations obtained on 120 plates. The plates also contain 359 observations of the 22 new stars scheduled for inclusion in the PZT programme from 1971 April. The Herstmonceux observations of these stars have now been reduced and the star place corrections have been computed. The adopted place corrections will take into account the observations of these stars with the Calgary PZT. The observations of the two instruments have also been combined in an investigation of the polar motion; the results are of special interest at present for the study of the improvements that should be achieved in the International Polar Motion Service by the equipment of the ILS stations with PZTs.

The PZT time and latitude observations for the years 1958–1967 were re-reduced this year using the star positions adopted in 1968 and with the revised value of the constant of aberration. The new UT1 results for the same period are now based on the OCI mean pole used in current reductions, since the beginning of 1968. The Cookson observations of the variation latitude at Greenwich between 1916 and 1936 have been combined with the contemporary latitude observations of the Washington PZT in an investigation of the polar motion over the period.

The rate of rotation of the Earth has remained constant from about mid-February 1969 at 2·7 ms per day losing relative to the atomic time scale defined in terms of ephemeris time. By international agreement the offset of the carrier frequencies of the co-ordinated radio time signals remained at -300 parts in 10^{10}, which is equivalent to a losing rate of 2·6 ms per day.

The Greenwich atomic time scale, GA2, based on caesium standards at Herstmonceux has been published quarterly in the *Greenwich Time Reports*. The co-ordinated time scale UTC (RGO) is determined arithmetically from GA2. GA2 and thus UTC (RGO) have diverged by less than 3 μs during the year from the corresponding international time scales, AT and UTC, computed by the B.I.H. International comparisons of atomic and UTC time scales have been made to this accuracy by measurements of Loran-C pulses and by travelling atomic clocks. The U.S. Naval Observatory has made three visits with casesium standards on regular flights.

In September the RGO took part in an experiment, operation 'Synchran' (Synchronisation Atlantique Nord) employing a method developed by the French Office National d'Études et de Recherches Aérospatiales for precision intercomparisons between remotely situated clocks. The time difference between a clock carried in an aircraft, whilst the aircraft is in flight, and a clock on the ground, was measured.

The aircraft passed over the Paris Observatory, the Royal Greenwich Observatory, the laboratories of the National Research Council in Canada, and the U.S. Naval Observatory. The scatter of the measures made at Herstmonceux was about 50 ns in bad weather conditions and 30 ns in good weather.

A complete programme of modernization of the time service installation is being continued incorporating recent developments in electronic techniques. An automatic comparator produces a printed output and a punched tape record of time comparisons between the caesium standards and between one standard and the output of the Loran-C receiver, three times daily to an accuracy of one-tenth of a μs. There are now four caesium standards at the RGO one of which has been continuously in use since March 1967 on low beam current.

THE SUN

The Sun was photographed at Herstmonceux in white light on 295 days and in Hα light with the Lyot filter on 208 days. Photographs in white light were taken on 249 days at the Cape.

The Lyot Hα heliograph at the Cape was in operation for 1640 hr during the year and 5000 ft of film were sent to the University of London Observatory for detailed study.

Major fluctuations resulted in an unusually small decrease in the level of solar activity compared with 1969. Current information was widely distributed by monthly Royal Greenwich Observatory Solar Activity Circulars.

PHYSICS

Kron Electronic Camera

Two electronographic image tubes have been made following the design developed by Dr G.E.Kron at the U.S. Naval Observatory, Flagstaff. The plate-holder section of these tubes has been modified by the inclusion of a thin mica window for isolating the photocathode from the electronographic plate. This eliminates the necessity for cryogenic cooling of the plate which is now changed through a vacuum lock designed to protect the mica window from atmospheric pressure. The time taken for this operation, which is fully automatic, is only 2 min.

S9 and S11 photocathodes have been successfully processed and laboratory evaluation of the tubes is now in progress. The vacuum lock plateholder has operated satisfactorily, but some difficulty has been experienced with stability of focus and with dark current. Tests with the tubes on the 36-inch Yapp telescope are planned for mid-1971

and it is hoped that they will eventually be used for direct photography in the Southern Hemisphere on the 40-inch telescope at Sutherland.

The development of these tubes has been carried out in collaboration with the U.S. Naval Observatory. Dr Kron visited Herstmonceux for 4 weeks in November, and one of the vacuum-lock plateholders is to be tested on the electronic cameras at Flagstaff.

Magnetically focused tube

An electronographic tube, focused by parallel electric and magnetic fields, has been designed and most of the parts for two such tubes, which are of demountable construction, are being manufactured. The diameter of the photocathode and mica window is 40 mm and a vacuum-lock plateholder of the type developed for the Kron tube is being incorporated. Other special features are a photocathode formed directly on the tube faceplate, and a high-voltage lead and potential divider insulated by the tube vacuum and silica envelope.

The design of the photocathode processing equipment for this tube is well advanced. The equipment will enable the mica window to be sealed on after the photocathode has been deposited from evaporators inserted through the output end of the tube. Since the construction and commissioning of this apparatus will take several months, the initial testing of the tube will be done using a gold photocathode (sensitive only to ultra-violet) incorporating a resolution test pattern.

Mica windows

Techniques for sealing large area mica windows have been developed and test equipment for studying the application of electronographic plates and film to the windows has been built.

Photocathode processing

A demountable vacuum system has been constructed for the investigation of photocathode processing methods. S1, S11, and S20 photocathodes will be studied with a view to their formation in the magnetically focused tube. Special attention is to be paid to uniformity and stability.

Electron optics

Good progress has been made in the theoretical analysis of image tubes focused by parallel electric and magnetic fields. The imaging properties of tubes having several different combinations of electrode shapes and potentials and operating in a uniform magnetic field have been computed. Work is in progress on the computing of the magnetic fields of realistic solenoids, both with and without magnetic shielding.

Image distortion caused by small deviations of the electric and magnetic fields from uniformity have been investigated theoretically. This work is being done in collaboration with the Applied Optics Section of the Physics Department in The Imperial College of Science and Technology.

Data reduction

Computer programs have been developed to permit the linearity of response and the high information storage capacity of electronography to be exploited in stellar photometry. The programs will operate on data written on to magnetic tape by a Joyce-Loebl digital microdensitometer scanning direct images of star fields (or other objects) obtained with electronographic image tubes.

INSTRUMENTATION

Isaac Newton Telescope

The astrometric properties of the Wynne field corrector at the prime focus of the I.N.T. have been investigated. The field distortion (1·6 per cent at 20′ off axis) is found to be within 0·01 per cent of the design value. The average s.e. of a star position over a field of 30′ × 30′ introduced by the corrector, does not exceed 0″·04.

Spectrographs

The first of two Cassegrain spectrographs of modular form designed to use either image intensifiers or photographic recording was installed in October, at the Radcliffe Observatory, Pretoria, after the completion of proving trials carried out on the 36-inch Yapp reflector at Herstmonceux earlier in the year. With the present choice of three gratings and a camera focal length of 192 mm, the linear dispersions available are 23-55-155 Å m^{-1} in the blue and 49-112-155 Å mm^{-1} in the red. The image intensifiers originally provided are the 'Spectracon' with S11 and the Carnegie system with S20 photocathode response. Electronic spectrum broadening is available for both image tubes. The system also provides an exposure meter which can function as a single-channel photoelectric photometer when required. A protective frame surrounds the instrument and carries some of the electronic equipment. An acquisition and off-axis guiding unit is incorporated in the modular form, which also has the usual entrance slit guiding facility.

Cape 30-inch reflector

The construction of a new mounting and tube for this telescope is in progress.

Photometers

The two-channel 'People's Photometer' has been designed in detail, manufactured and tested on the 28-inch refractor. Five of these instruments have been manufactured for distribution to various observatories. This instrument is designed to operate with one of its two optical channels monitoring the sky brightness, but can be converted readily to operate with a beamsplitter. In the latter form, useful observations may be made in 'non-photometric' conditions.

The two-star comparison photometer has been delivered by the manufacturers and preparations are being made to mount and test it on the 36-inch reflector. Pulse counting and timing equipment for use on the St Andrews photometer has been completed.

New solid-state d.c. amplifiers designed at Herstmonceux have been built and put into service at the Cape. Some of the older EHT power supplies for the photometers have been replaced by new units built at St Andrews University Observatory.

Miscellaneous

A quartz prism of 10-cm diameter and one arc minute angle has been provided in a removable mounting in front of the 26-inch refractor lens. This produces secondary stellar images on the plate of about 30 arc seconds separation and $4^{m}{\cdot}0$ difference to enable photographic calibration (as suggested by Racine) to be evaluated.

A fixed format projector for the determination of approximate X-Y co-ordinates of star images has been provided for use by the Astrometry Department. This enables the search phase of the GALAXY machine to be omitted for plates which do not require a large number of star positions to be determined, but do require the full measuring accuracy of the search phase.

A Joyce Loebl Autodensidator Mk III with Racal-Thermionic Magnetic Tape Recorder was acquired and, after acceptance trials, taken into use by the Astrophysics Department.

H.M. NAUTICAL ALMANAC OFFICE

Ephemerides

The following almanacs have been published during the year: *The Astronomical Ephemeris* for 1971; *The Nautical Almanac* for 1971; *The Air Almanac* for 1970 September to 1971 August (in three parts); *The Star Almanac for Land Surveyors* for 1971. The data for the first parts of the *Astronomical Ephemeris* for 1974 and 1975 were distributed in the form of reduced-size Xerox copies of computer listings in June and August. In addition the Office has prepared and distributed

special predictions and ephemerides including: world-wide predictions of lunar occultations of stars and of radio, X-ray and infra-red sources; maps of the tracks of grazing occultations; prediction of occultations of stars by planets; topocentric ephemerides of the Moon for radio observatories; transit ephemerides of planets for Herstmonceux and the Cape; co-ordinates of the Earth with respect to the centre of mass of the solar system for use in the reduction of pulsar observations; and rising and setting times, etc., for particular places, as well as general astronomical and calendarial information, to meet civil requests.

Progress on the production of the new *Sight Reduction Tables for Marine Navigation* has again been slower than anticipated. Reproducible material for the tabular matter for all six volumes has been received from U.S. Naval Oceanographic Office, but the explanatory material has been received for only one volume.

The programs for automatic editing and composition for the photo-setting of the tabular data in the almanacs have been revised and extended so that the powerful facilities of a Linotron 505 filmsetter can be used in future.

Research activities

The programme for the prediction, reduction and analysis of occultations of stars and radio sources by the Moon has been continued under the supervision of Mrs F.M.Sadler. The digitization of Watts' charts of the marginal zone of the Moon has been completed and copies of the data tapes have been supplied to other establishments. An account of the methods of preparation and use of these data has been written. The reduction of occultation observations can now be carried out automatically once the information received from observers has been examined, coded and punched.

The large number of observations of occultations of the Pleiades has made possible the separation of the effects of accidental and systematic errors in timing from those due to errors in the star places and in the lunar ephemeris. The comparison of visual and photoelectric timings showed that, because of the presence of errors in the star places, the high timing accuracy of the photoelectric observations cannot normally be fully utilised in the analysis for ephemeris errors. (The light curves give, however, much valuable information about the occulted stars.) An investigation of the personal equations associated with different methods of visual timing is in progress.

A preliminary analysis of the observations of grazing occultations has shown that this technique will provide useful information about those elements of the Moon's orbit that are only weakly determined by total occultations and about the equinox correction of the star

catalogue. Arrangements have been made for the publication of tracks in various astronomical handbooks and detailed predictions are provided on request to organisers of suitably-placed observing teams.

A new catalogue of the positions of radio sources that may be occulted by the Moon has been prepared for use in the regular prediction programme. Predictions are also made for X-ray and infra-red sources as the successful observation of any such occultations using instruments on rockets or balloons should give much improved positions, and hence facilitate the identification of these sources. Details are provided on request to interested observing groups.

Mr L.V.Morrison has examined again the discrepancy between the theoretical and observed motions of the Moon's node and has been able to show that, by combining a result from our recent analysis with a corresponding result from Spencer Jones' work, the discrepancy can be reduced from 11″ to 5″ per century. It seems likely that the discrepancy will not be satisfactorily resolved until the observations from 1900 to 1960 have been analysed by modern techniques.

A new theory of the motions of the satellites of Mars has been developed by Dr A.T.Sinclair, but the determination of new orbital elements is not yet complete. The results so far obtained appear to confirm earlier results based on a simpler model, but the reduction in the residuals has been disappointingly small. He has also studied heliocentric orbits with high eccentricities and mean motions that are commensurable with Jupiter's mean motion. The results suggest that it is unlikely that the few minor planets now in permanent libration with Jupiter are dead comets that were captured by Jupiter.

Studies of precession, planetary masses and time systems, etc., were made in connection with I.A.U. Colloquium No. 9 (held at Heidelberg in August) on the subject of the I.A.U. system of astronomical constants. Reports of the proceedings of this Colloquium, and of the meetings of I.A.U. Commission 4 at the General Assembly, have been prepared for publication.

Computer service

A multiplexor and three remote teletype consoles were added to the ICL 1909 computer system in May, but their use has had to be restricted as the additional operating-system programs are larger than expected. The exchangeable-disc stores are now being used extensively and have reduced considerably the time required for many regular jobs. The computer has continued to be reliable with an average serviceability ratio of 0·97. The average amount of useful computer time (i.e. excluding time lost for faults and all hardware

maintenance) has increased to 44 hours per week. Of this, 23 per cent has been for N.A.O. work, 39 per cent for the rest of the Observatory, 27 per cent for external users (Natural Environment Research Council and Ministry of Defence), and 11 per cent for systems software maintenance and development, etc. The Computer Section has continued to provide a programming advisory service and a punching service for all users, in addition to operating the computer.

GENERAL

On 1820 October 20 the Ordinance inaugurating the Royal Observatory at the Cape of Good Hope was signed and in 1970, therefore, the observatory celebrated its 150th Anniversary. To mark the occasion a booklet giving an outline history of the observatory was produced and distributed **(32)**. On December 4 a Visitation Day attended by leading men of science and public life in South Africa was held, the principal speaker being Dr S.M.Naudé, the President of the South African Council for Scientific and Industrial Research. On December 5, an Open Day for the public attracted about 800 visitors.

In September, agreement in principle to a new joint venture in astronomy was announced by the Science Research Council and the South African CSIR. The new South African Astronomical Observatory, to be operated jointly by the two agencies, will consist of a base station in the grounds of the present Royal Observatory and an observing outstation at Sutherland about 230 miles from Cape Town on the Karroo. The new observatory will come into being on 1972 January 1, when the present Royal Observatory will cease to operate under that name. On that day the first Director, Sir Richard Woolley, will take up his appointment on retiring from the post of Astronomer Royal. Meanwhile the new outstation, to be financed by the CSIR, is being planned, and it is hoped that building will actually start in March 1971.

The Herstmonceux Conference was held at the Castle on 1970 April 13 and 14, the subject being 'Distances and Sizes of Cosmic Objects'. The principal overseas speaker was Professor Th. Schmidt-Kaler of the Ruhr-Universität Bochum.

The XIV General Assembly of the International Astronomical Union took place at Brighton from 1970 August 18 to 27. A number of RGO staff helped in the local arrangements, which were directed by Dr D.H.Sadler as Chairman of the Local Organising Committee. The Assembly was widely acclaimed a great success: it is equally widely recognized that this was due in great measure to the skill and experience of Dr Sadler, who is, of course, a former General Secretary of the

Union. Parties of participants were entertained at the Observatory on the afternoons of each working day during the Assembly.

The Astronomer Royal acted as Scientific Director for a NATO Advanced Study Institute on 'Stellar Evolution and Variable Stars' held at Ofir, Portugal, in early September. Five senior members of the RGO staff attended as lecturers and two juniors were included amongst the UK students present.

The use made by guest investigators of the 30-inch and 36-inch reflectors has now assumed such proportions that an internal Small Telescope Users' Panel has had to be instituted to apportion observing time on these instruments.

Mr D.H.Sadler was awarded an honorary doctorate by the University of Heidelberg on May 13.

Sir Richard Woolley was awarded an honorary Sc.D. by the University of Sussex on August 24.

Dr D.Lynden-Bell and Dr B.E.J.Pagel have been made Visiting Professors at the University of Sussex.

PUBLICATIONS

The following publications have appeared during the period under review, in addition to the routine publications of the Nautical Almanac Office which are referred to in the corresponding section of this Report.

Royal Observatory Annals No. 4 (Observations of Stellar Parallax, III) and the Greenwich Time Reports for 1969 January–December and 1970 January–March, were published anonymously. Other papers which have appeared in Royal Observatory Annals, Bulletins or elsewhere, are listed below.

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