

Proceedings of Observatories

ROYAL GREENWICH OBSERVATORY

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

ROYAL OBSERVATORY, CAPE OF GOOD HOPE

(Director, *Professor R. H. Stoy, C.B.E., H.M. Astronomer*)

(Report for the year ending 1965 March 31)

CLUSTERS

(i) ω Centauri

Analysis of the astrometric and photometric data on this cluster has been completed. An HR diagram virtually freed of field stars has been obtained. The general features are typical of extremely metal-poor clusters in having a predominantly blue population of the horizontal branch. Stars on the red side of the variable gap seem to be approaching (or leaving) the giant sequence asymptotically. The brightest giant stars have been studied on many plates and the considerable spread in colour which is observed in this region is undoubtedly real. Many of the reddest stars in this region appear to be small-amplitude variables. A study of stars in the region of the RR Lyrae variables indicates that very few (if any) non-variable stars populate this region of the HR diagram. There is no evidence for significant variation amongst the blue stars closest to the variable-star region.

Analysis of the mean distribution with radius, of stars in different regions of the HR diagram, indicates that only the RR Lyrae variables appear significantly less concentrated towards the centre than other groups. The ellipticity of the cluster increases with radius from the centre out to a maximum at a radius of about $5'$ after which it gradually falls to nearly zero in the outer parts. Comparison with a theoretical model indicates that the inner parts of the cluster are in solid-body rotation. The model is shown to be consistent with the velocity dispersion and rotation observed from radial velocities of individual stars.

A mean density distribution with radius representing the undistorted cluster has been compared with various cluster models computed using the ICT 1201 computer. A very good fit has been obtained with a model based on full equipartition of energy among stars of different masses.

This result could indicate a predominance of radial orbits, at least in the early stages of the cluster's formation, since in the lifetime of the cluster, stars in radial orbits will have relaxed much further out in the cluster than stars in circular orbits.

(ii) 47 *Tucanae*

A selection of about 1500 stars in an annulus with radii 7' and 25', centred on the cluster, has been chosen for astrometric measurement on Cape 24-inch plates. So far, two first-epoch plates (1902) and one modern plate (1964) have been measured.

The photometric programme has been completed. Measures on up to four plates in each of the two colours *B* and *V* have been made for 4828 stars in the cluster in an annulus between radii 3' and 30'. A final catalogue of magnitudes has been prepared and analysis of these data will proceed on the completion of the astrometric part of the programme.

(iii) NGC 2168 (*M* 35)

Two pairs of Mount Wilson 60-inch plates on this cluster have been measured astrometrically. The better of the two pairs will give proper motions of over 1200 stars, and the other pair rather less than 1000. It is planned to reduce the measures in a more complex manner than hitherto. A program is being written for the IBM 7094, which includes second-order plate constants and iterates until a selection of standard stars with sufficiently small dispersion is obtained.

Unpublished magnitudes and colours of many of the faint stars, on the (*R,G,U*) system, have been made available through the courtesy of Professor W. Becker. It appears that the astrometric investigation extends to $G = 16.5$ although the measures are incomplete to at least one magnitude brighter than this.

(iv) *Hyades*

Discussion of the proper motions deduced from Mount Wilson plates has been completed. Of 69 possible candidates, 21 are suspected as being true members, but of these, only 5 appear not to have been noted by other workers. The number of faint members ($m_{pg} > 10$) found in this survey is in fair agreement with the work of Giclas, Burnham and Thomas from Lowell plates, but is considerably in excess of van Bueren's estimate.

(v) NGC 6522

The measurement of proper motions of some 600 stars within 3' of the cluster centre, on two plate pairs taken with the Mount Wilson 100-inch reflector, is now complete. The quality of the images and the

degree of crowding in this field meant that stars fainter than $B = 17.5$ were unsuitable for proper-motion determination on so short a base-line as 17 years. A fairly significant proper motion of $0''.003$ per annum between some brighter cluster members and a group of field stars has been found; this motion is mostly in the direction of galactic rotation.

(vi) *Other clusters*

A programme to obtain B and V plates of some possibly old galactic clusters has been started, with a view to obtaining preliminary colour-magnitude diagrams for these objects. A total of 15 cluster plates have so far been obtained.

Sixteen plates of globular clusters have been secured as the start of a programme to study variable stars of special interest in these clusters.

(vii) *Theoretical work*

A large number of orbits in the restricted three-body problem have been computed using the ICT 1201 computer, with a view to solving the following problems:

(1) How are orbits of stars in the outer parts of globular clusters affected by the tidal field of the Galaxy?

(2) What is the effect on a stellar 'group' when it makes a close approach to a knot of gas, or part of a spiral arm, in the potential field of the Galaxy? It soon became evident that a complete solution of the first problem would necessitate the use of a larger and faster computer, in view of the large number of orbits and more general formulation of the problem necessary for such a complete solution. However, some interesting orbits were obtained, in particular some periodic and near-periodic orbits in the case where no 'surfaces of zero velocity' (Hill surfaces) exist in the X - Y plane (positive constant of integration).

Some progress has been made with the second problem enumerated by allowing a group of stars with common space velocity to pass a mass of gas in an inverse-square galactic field. Preliminary results using a knot of 100 solar masses at a distance of 10 kpc from the galactic centre indicate that in fact the effect of the knot is fairly small. The stars in the group merely re-arrange their velocities slightly without substantially changing their galactic periods. The close approach to the mass of gas has the expected effect of perturbing circular orbits into slightly elliptical ones.

GALACTIC RR LYRAE VARIABLES

The absolute proper motions of 43 RR Lyrae variables in the Greenwich, Oxford and Vatican Carte-du-Ciel zones have now been obtained.

In the course of this work, an examination has been made of the relative merits of the reduction from relative to absolute proper motions by using

- (a) secular parallaxes of faint reference stars ($m_{pg} \sim 11$) and
- (b) meridian observations of brighter stars ($m_v \sim 8.5$).

The former method has proved to be preferable, and furthermore, an empirical rule

$$p_m n_m^{1/3} = \text{constant}$$

over the whole sky gives as good a measure of the parallax as any. Here p_m is the mean parallax of stars of magnitude m and n_m is the number of stars per unit area whose magnitude is brighter than or equal to m .

The importance of securing the absolute proper motions on a homogeneous system cannot be too strongly emphasized.

Although the proper motions of some of the variables have been determined by other investigators, these are the first plate-to-plate determinations for these stars. It has now been established, from an examination of all other available proper motions of RR Lyrae variables, that there is no great loss in accuracy when they are obtained from positions on modern astrographic plates compared with the *Astrographic Catalogue*. With a base-line of 60 years, and using 20 reference stars, a standard error of $\pm 0''.005$ in the annual proper motion can be obtained. For this reason, a more extensive programme to obtain proper motions of RR Lyrae stars in other zones has been initiated. It is intended to use the plate-to-catalogue technique to obtain proper motions of all such variables north of $\delta = -10^\circ$ which appear in the *Catalogue*, and for which no data are available. Work on some 25 of these stars is now nearing completion.

A list of 144 RR Lyrae stars in the southern sky has been compiled and second-epoch plates are currently being secured with the Cape astrographic telescope.

The astrographic telescope at Herstmonceux has been used to obtain periods and B light curves of RR Lyrae stars. The magnitude scale in the variable field is established by superimposing a cluster field containing a photoelectric sequence on the same plate. The method has been checked on two RR Lyrae stars with photoelectric light curves. The mean magnitudes are within $0^m.1$ of the photoelectric values.

The Cassegrain spectrograph of the 74-inch telescope at Kottamia in the United Arab Republic was used in 1964 November–December and again in 1965 March to obtain spectra of some of the brighter RR Lyrae stars. The dispersion used was $67 \text{ \AA/mm}$ at $H\gamma$. Radial-velocity curves for 4 stars and mean velocities for 3 others were obtained from the 1964 plates.

The 74-inch reflector at Kottamia has also been used, with the 28-inch refractor at Herstmonceux, to construct the light curves for six RR Lyrae

stars—SS Psc, AH Cam, UY Cam, TT Lyn, RY Com and AV Peg; the first three are in three colours and the last three in two on the (U, B, V) system. None of the three for which three colours are available showed the enhancement of $U-B$ during rising light, as has been found elsewhere for several variables. The largest reddening found is for AH Cam with $E_{(B-V)}$ near $0^m.6$.

Further analysis of the available radial velocities and proper motions indicates a period–luminosity law for galactic RR Lyrae stars not significantly different from

$$M = 0^m.0 - 2.5 \log P.$$

All the stars with periods greater than $0^d.44$ have high space velocities whilst those with shorter periods, with seven exceptions, have low velocities. The exceptions, however, are all those short-period stars with large Δs —the characteristic which normally accompanies the long-period stars.

RITZ THEORY OF LIGHT EMISSION

A number of plates of the quasi-stellar radio source 3C48 have been secured on the 26-inch refractor, with the object of detecting any differential aberrational shift of its image against those of stars nearly in the same line of sight. The spectrum of the object shows a red shift of $0.4c$, so that according to the Ritz theory (Dingle 1959, *Mon. Not. R. astr. Soc.*, **119**, 67) its aberrational shift should be 1.67 times larger than that of a star. Measurement of a pair of plates on which the predicted shift (according to the Ritz theory) should be 200μ yields a shift of less than 10μ . This null result is confirmed by measurements of other extragalactic sources made at Pretoria. The conclusion is either that the Ritz theory is untenable or that the observed red shifts are not due to recession.

ASTROPHYSICAL SPECTROSCOPY

Studies of abundances in G and K dwarfs based on low-dispersion spectra have been continued using about 200 plates taken with the $f/1.75$ (80 Å/mm) camera of the Yapp Cassegrain spectrograph. The $\lambda 3800$ CN feature, the strength of which was previously found to be correlated with metal abundance, has been measured. Preliminary results suggest that there are some departures from a one-to-one relationship between ultraviolet excess and CN strength even for stars having the same temperature and luminosity.

For G and K giants, the narrow-band photometric measurements published by the Cambridge observers have been used to derive a parameter which shows a correlation with the iron : hydrogen abundance ratios found for these stars from curve-of-growth analyses.

An investigation has been made into the metal abundance and ultra-violet excess of the Sun relative to the Hyades. Electron pressures obtained from curve-of-growth analyses by G. Wallerstein reveal an apparent inconsistency if the Sun and the Hyades are assumed to have the same metal : hydrogen ratio. A combination of the available spectroscopic and spectrophotometric data suggests that the Hyades have an iron: hydrogen ratio exceeding that of the Sun by about 0.2 in the logarithm, corresponding to an ultra-violet excess for the Sun of about $0^{\text{m}}.05$. Both Wallerstein's data and the solar ratio of the intensity of $H\delta$ to that of adjoining Fe I lines, measured from Yapp Cassegrain spectra of Jupiter's satellites, suggest that the actual value of $(B-V)$ for the Sun (uncorrected for blanketing) should be about $0^{\text{m}}.66$.

A rough abundance analysis has been made by Sargent of the F-type supergiant HD 116745, a member of the globular cluster ω Centauri. The analysis was made on 86 Å/mm Radcliffe plates using MK standard F-type giants recorded on the same plates for comparison. The star was found to be metal-deficient by a factor of about 40. Its spectrum shows strong interstellar absorption lines although the cluster is not very much reddened.

Using Mount Wilson plates of the star HR 8752, Go Ia, Sargent discovered forbidden emission lines of [N II], λ 6547 and λ 6583, which appear to arise in an extended envelope. This is the first discovery of forbidden lines in the spectrum of such a cool supergiant.

Following discussions on magnetic stars with W. A. Fowler, F. Hoyle and E. M. and G. R. Burbidge, Sargent has suggested that the λ Bootis stars (metal-weak, low-velocity A stars) may well be a kind of Ap star in which all the elements have been destroyed by spallation at the surface.

Thirty-six plates of α Boo have been obtained with the coudé spectrograph in order to carry out a more detailed study of the variation in intensity and profile of the H_2 and K_2 emission components, discovered by R. F. Griffin. Short-term alternations (within hours) were found in the ratio of red to violet components, with frequent disagreements in this ratio between H and K, but they are not much larger than the errors of measurement and they show no sign of periodicity. Only a marginal correlation has been found between the violet : red ratio and the velocity shift between emission and absorption components; the latter seems in any case to be too small to account for the variations observed. The intensity ratio of K_2 to H_2 is not much above unity, so that in this case Z. Suemoto's hypothesis of emission in optically thin layers is not confirmed. It is hoped that a series of heavier exposures to be taken in the 1965 season will yield more definite results.

The coudé spectrograph has also been used by Dr A. Przybylski for a

study of the Eu-Cr type magnetic star HD 9996, which is found to have lines of ionized holmium, and by Dr W. L. W. Sargent for a study of several λ Bootis type stars. One of these, 2 And, was found to have interstellar H and K lines despite its distance of only 18 pc based on a good trigonometric parallax. The only closer star in which interstellar lines have been found is α Ophiuchi.

A massive programme of spectroscopic and theoretical ground-work is being carried out as a preliminary to the abundance analysis of plates accumulated from Mount Wilson and Mount Stromlo Observatories. This has involved extensive measurements of equivalent widths on Moon and sky plates taken at Herstmonceux and Mount Wilson respectively, checking their accuracy by reference to the photoelectric equivalent widths at various points of the solar disk obtained by E. A. Müller and P. Mutschlecner (MM). It was found that reasonably accurate equivalent widths were obtained from direct-intensity tracings by representing most lines as triangles or trapezia. Except in the case of the very strongest lines, any attempt to include the apparent wings of the lines led to equivalent widths that were too large.

The MM equivalent widths have also been used to check solar line intensities measured by C. W. Allen, K. O. Wright, the Utrecht observers and H. L. Helfer & others. Most of these series contain systematic or random errors which cannot be rendered innocuous in differential analyses by simply feeding solar line intensities obtained with a stellar spectrograph into a standard solar curve of growth. The best estimate of solar line intensities (other than those measured by MM) appears to be a straight logarithmic mean of the values given in the Allen and Utrecht tables; for weak lines having $\log (W/\lambda) < -5.0$, a small systematic correction of $+0.03$ in the logarithm should be added to these mean values.

Apart from the problem of measuring equivalent widths, problems have been found to arise in connection with the shape and uniqueness of the solar curve of growth. Using the extensive data on f -values from the arc measurements at the U.S. National Bureau of Standards, it is found that most solar lines of titanium, chromium and iron lie on the van der Held curve of growth recently published by C. R. and A. P. Cowley (CC), which resembles the theoretical curves computed earlier by L. Goldberg, E. A. Müller and L. H. Aller, but lies considerably higher than the older Milne-Eddington curve of Goldberg and Pierce which has been widely used in differential analyses. In the case of Fe I a further problem arises because of the variation in damping constant among different multiplets, suggested by various authors since 1948, in the sense that certain high-excitation multiplets having 'odd' lower terms have an exceptionally large damping constant, while the resonance multiplets

have an exceptionally low damping constant. This effect is particularly important in the differential analysis of weak-lined stars, in which it tends to lead to under-estimates of the stellar excitation temperature compared with that of the Sun.

Consideration of this effect has led to a preliminary reappraisal of the abundances of heavy metals in the halo red-giant star HD 122563 analysed by G. Wallerstein & others on the basis of Mount Wilson and Palomar plates. These authors, and also Pagel on the basis of Radcliffe Observatory plates, had obtained a value of $\Delta\theta_{\text{ex}}$ that was anomalously large for the effective temperature of the star deduced from six-colour photometry, because of their use of the Goldberg-Pierce curve of growth for all the solar Fe I lines visible in the star. Elimination of this assumption leads to a large change in the abundances of the heavy metals Sr, Y, Zr, Ba, Ce and Eu, which had all been found to be deficient relative to iron by large factors; it is now found that only Ba, Ce and Eu are significantly deficient (by factors of 10 or more) compared with their solar abundances relative to iron. This result is of interest in connection with other evidence from abundances in the solar system and in the Ba II and CH stars that two separate processes of slow neutron capture may be involved in the production of zirconium and lighter elements on one hand and barium and heavier elements on the other. The existence of strontium, yttrium and zirconium in almost normal proportions relative to iron in such an old star as HD 122563 suggests that these metals were formed simultaneously with the iron group itself, or at least very shortly afterwards.

Final reductions are now being made with the IBM 7094 of the radial velocities of the A-type stars mentioned in previous reports. A rotational velocity has been estimated for all the stars and spectral types and luminosity classes derived on the MK-system from several plates per star for over 600 stars.

In order to test the long-term stability of the coude spectrograph attached to the 30-inch reflector at Herstmonceux, a programme of observations of the 26 IAU standard radial velocity stars available to the instrument has been carried out. At least four spectra of each star have normally been obtained. Observations of the Moon have also been secured throughout the year. The majority of these plates have already been measured and the results are very satisfactory.

The internal standard error of a single plate for stars later than Fo is normally between ± 0.3 and ± 0.5 km/s and the indications are that the true s.e. of a stellar velocity, obtained by plate-to-plate comparisons, will be less than twice these values.

The general radial-velocity work at Pretoria, which concentrates mainly on stars thought to be near the Sun and on subdwarfs, has con-

tinued steadily. A list giving for 200 stars newly-determined radial velocities, MK spectral types and three-colour photoelectric magnitudes and colours has been completed and will form the body of the sixth paper in the series 'Fundamental Data for Southern Stars'. A number of newly discovered subdwarfs are included in this list. The data for twelve spectroscopic binaries have been worked up ready for solution by the computer at Herstmonceux.

The Radcliffe Newtonian spectra have yielded velocities for nine extragalactic systems, only one of which had been previously observed. This brings the total of southern galaxies observed with the Newtonian spectrograph to 43. The radial velocity of a ring of gaseous nebulosity in the Large Magellanic Cloud has been measured. This gaseous loop appears to be about 100 parsecs in diameter or about 17 times bigger than the Cygnus Loop in our own Galaxy, which it somewhat resembles.

POSITIONAL ASTRONOMY

The final results of the 75 000 observations made at Herstmonceux for the international AGK3R programme were presented (in the form of a machine listing) to Mr F. P. Scott of the U.S. Naval Observatory, Washington, as co-ordinator of the programme, when he visited Herstmonceux in August. It was then agreed that the data should be supplied for computer processing in Washington as a magnetic tape rather than as a consignment of 75 000 punched cards weighing $3\frac{1}{2}$ cwt. The information was therefore transferred from cards to tape, and sent to Washington in December. Duplicates of the transmitted material (in the form of cards, listing and magnetic tape) are held at Herstmonceux. A computer programme for preliminary analysis of these observational results is being written.

The preparation of an up-dated observing catalogue for the Herstmonceux transit circle has been mechanized. Bulk is reduced by excluding stars for which the required observations have been completed, and certainty of star identification is improved by precessing the star positions to a current date. The process has given an opportunity of adding some 29 variable stars to the programme, and of including additional catalogue entries for separate components and mean of close double stars. The list of times and circle-settings for meridian planetary observations is now prepared entirely by punched-card computer methods.

At the Cape, observations for both the bright and faint star lists of the international SRS project have been continued. A comprehensive investigation of the figure of the pivots of the transit circle was made using both the axial microscope and the axial collimator methods. The results

obtained agree very closely with the 1960 determinations which were made just after the pivots had been reground.

The Danjon prismatic astrolabe has been transferred from Herstmonceux to the Cape, where it is installed in a new pavilion with cavity walls. An air-conditioning unit keeps the instrument when not in use, at the expected operating temperature for the next duty. Small platinum resistance thermometers continuously monitor the temperature difference between the back and front faces of the prism. The instrument will be used primarily to derive systematic corrections to the fundamental FK4 system between -4° and -64° declination.

The results obtained with this instrument whilst it was at Herstmonceux have been analysed. Small but significant differences between the various observers were found for $\Delta\alpha$ and $\Delta\delta$ as well as for the time and latitude results. Comparisons have been made with FK4, N30 and the Paris astrolabe results. The four catalogues appear to be comparable as regards both systematic and accidental errors.

TIME SERVICE

Observations with the PZT during the period 1958.0 to 1964.2 have been analysed with a view to determining corrections to the star positions adopted in 1958. This analysis has shown that the errors in both coordinates are small and seldom exceed $0''.1$ for individual stars. The analysis also confirms the existence of a large closing error in declination, of the order $0''.5$, arising from an apparent diurnal variation in latitude. The results suggest that this apparent diurnal change is in part associated with the instrument itself and is probably related to temperature changes; precise differential temperature measurements are now being made within the telescope. Pending the results of these measurements it is not possible to derive new declination corrections to the star places. It has been decided not to apply the adopted right-ascension corrections until the declination corrections have been deduced.

Owing to the effects of precession, a number of stars included in the current programme of observations can no longer be observed with the PZT. These stars, together with a number which have proved too faint for routine observation, are being replaced in the new programme of observations commencing 1965 April 1. The replacement stars have been observed with the PZT in the past two years and the work of reducing their positions to the PZT system of places is almost completed.

The observed rate of rotation of the Earth has continued to decrease, by approximately 0.00026 milliseconds per day per day; the average losing rate relative to Ephemeris Time, made available by atomic standards, was 2.0 milliseconds per day.

By international agreement the offset for the carrier frequencies of the coordinated radio time signals remains at -150 parts in 10^{10} for the calendar year 1965; this is equivalent to a losing rate of 1.3 milliseconds per day. The big difference between this rate and the rate of rotation of the Earth has necessitated four adjustments in epoch to the time signals, each of 100 milliseconds retardation. The adjustments were agreed internationally and made on 1964 April 1, September 1, 1965 January 1 and March 1. At the end of August and the end of December the coordinated time signals were emitted in advance of U.T.2 by about 130 milliseconds. British radio time signals were advanced 4.5 milliseconds on 1964 September 1, to bring them into line with other coordinated signals. A systematic error of one part in 10^{10} gives rise to a cumulative discrepancy of over three milliseconds in one year.

The transatlantic synchronization of radio time signals has become of such importance that three experiments, originating in the U.S.A., have been conducted with flying clocks. In October a quartz clock was compared with WWV at Beltsville (the emitting station), and brought by air to the U.K., where it was compared with MSF at Rugby and with clocks at the Royal Greenwich Observatory. On its return to the U.S.A. the clock was rechecked with WWV. This experiment helped to explain discrepancies of half a millisecond found in the timing of artificial satellites. In February another quartz clock, and later a portable caesium standard, were compared with clocks at the Observatory as part of a world-wide experiment.

If the difference in emission times of the two signals, WWV and MSF, is determined by the travelling clock, then it is possible to calculate the effective surface speed of the radio waves. The experiment made in October gave a value of 287 km/millisecond, and this figure was confirmed by the February experiments; but the reception of WWV was poor in February so that the result was not reliable. This figure is a little higher than that used at present for HF radio waves, i.e. 280 km/millisecond.

COMPUTING FACILITIES

The ICT 1201 computer in the Nautical Almanac Office has been used principally for the routine production of ephemerides and for the reduction of observations, while all new work has been programmed in Fortran and has been carried out by hiring time on an IBM 7094 computer system.

The Treasury insisted that the replacement for the ICT 1201 be selected by competitive tendering procedure, and so an evaluation team consisting of representatives of the Navy Department, the Treasury and the Observatory was set up in July. At the end of the report year an ICT 1909 com-

puter system was ordered for installation in 1966 March. This system will be about one hundred times more powerful than the ICT 1201 and can be further expanded if this should eventually prove to be necessary.

DYNAMICAL ASTRONOMY

A preliminary analysis of the observations of the satellites of Mars has led to an improved set of orbital elements, although further work is needed to determine the secular accelerations more precisely. A program for the determination of differential corrections to the orbital elements of visual binaries has been used to improve the elements for the stars ADS 450 and ADS 10087; the program is now being further developed to make it more flexible, but it will only be used on stars for which the observations have been carefully studied by an experienced double-star observer.

A program for predicting the position of artificial satellites to facilitate kinetheodolite observations has proved to be so successful that predictions are now also being supplied to the Royal Observatory at Edinburgh. Work has also been started on a series of programs for computing the special and general perturbations of a planetary orbit.

The adoption by the IAU of a new system of astronomical constants has already led to the necessity for the recomputation of some of the tabulations in the *Astronomical Ephemeris* and for the determination of corrections to bring the planetary and lunar ephemerides on to a uniform basis.

LUNAR OCCULTATIONS

New techniques for the analysis of the observations of occultations of stars by the Moon are being developed. Observations of a small number of grazing occultations have also been made (with the co-operation of B.A.A. observers) and analysed; the limb contours given in *Astr. Pap., Wash.*, Vol. XVII, have been generally confirmed but there is a puzzling discrepancy of $-0^{\circ}.2$ in position angle that is being studied.

The usefulness of lunar occultations of radio sources for the determination of precise positions of quasars, and of the distribution of intensity across extended sources, has resulted in much increased interest in the predictions supplied by the Nautical Almanac Office, and in direct co-operation between the Office and the observers in the reduction of the observations. The central reduction of such observations ensures that the deductions are made on the same systematic basis and that the maximum amount of information is abstracted from the observations at different stations.

Special predictions were also supplied for the successful observations, during a rocket flight from White Sands, U.S.A., on 1964 July 7, of the X-ray source associated with the Crab nebula.

GEOMAGNETISM

Manuscript world charts for all seven magnetic elements for the epoch 1965.0 have been prepared for publication by the Hydrographic Department, using all available data up to mid-June 1964. A considerable increase in the volume of data necessitated the development of new techniques. More sophisticated methods of analysis are being developed to cope with vast increases in the number and variety of data and with more exacting requirements for information based on the field parameters. The new methods will embrace not only surface rectangular components as at present, but also observations of any vector component or scalar, with any spatial distribution, whether the components and positions are given in geodetic or geocentric coordinates.

An automatic 3-component digital-recording magnetometer belonging to the Meteorological Office was installed at Hartland in October. However, despite all efforts, it became clear that any instrument based on a proton-precession sensor cannot function at Hartland for more than about a quarter of the time. The trouble stems from field modulations at a frequency of 50 c/s and its harmonics. A field survey in which noise up to the 50th harmonic of 50 c/s was detected, showed that the observatory lies near a preferential Earth-return path for leakages from the local power supply. A survey at Herstmonceux has shown that the 'noise' here is at a very low level and that the area is magnetically flat. A pilot scheme has been initiated to investigate the possibility of transferring at least some of the magnetic work from Hartland.

PUBLICATIONS

The following publications appeared during the year ending on 1965 March 31:
Royal Observatory Bulletins 81-90.

Astronomical Ephemeris 1966 (published 1964 September).

Astronomical Ephemeris 1969 (first part distributed 1964 November).

Nautical Almanac 1966 (published 1965 January).

Star Almanac 1965 (published 1964 May).

Air Almanac 1964 Part III (published 1964 April).

Air Almanac 1965 Parts I and II (published 1964 October and 1965 January).

Azimuth Diagrams—experimental edition (distributed 1964 July).

The 1966 editions of the *Astronomical Ephemeris* and of the *Nautical Almanac* are jointly the 200th edition of the *Nautical Almanac and Astronomical Ephemeris*.

that was first published for the year 1767. This anniversary is marked by the inclusion in the editions for 1967 of special prefaces and historical accounts of the development of the Almanac and by the publication of a modern account of the method of lunar distances in the *Journal of the Institute of Navigation*.

Royal Observatory Bulletins 83, 86 and 89 are Time and Latitude Service Bulletins, published anonymously. Other papers (published as *Bulletins* or elsewhere) are listed below:

- Atkinson, R. d'E., 1965. The speed of astronomical spectrographs, *Observatory* **85**, 35.
- Cousins, A. W. J., 1963. *UBV* standards in the equatorial zone, *Observatory*, **83**, 254.
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