1930MNRAS..90..724S

John Hasselkus, Director of Ross Limited, Optical Works, 3 North Side, Clapham, London, S.W. 4 (proposed by Charles A. Parsons);
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Alexander Raven Thomson, 30 Overstrand Mansions, London, S.W. 11 (proposed by W. A. Parr).

Eighty-five presents were announced as having been received since the last meeting, including—

Córdoba Observatory, Resultados, vol. xxxv. (Fundamental Catalogue).
International Astronomical Union, "Délimitation scientifique des constellations," par E. Delporte. Being the Report of Commission III.
Mount Wilson Observatory, Papers, vol. iv. (Mt. Wilson Catalogue of Photographic Magnitudes in Selected Areas 1–139).
P. Stroobant, Cartes célestes destinées spécialement à l'orientation dans les régions équatoriales.

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows :—

R.A.S.
Ref. No.
416. Pluto, Lowell Observatory, 42-in. reflector, *F.L.* 220 in., March 2d 4h 56m; March 5d 3h 44m. C. O. Lampland.
417. Solar Corona, 1929 May 9. Takengon, Sumatra, 6⅔-in. lens, *F.L.* 15 ft. Exp. 70 sec. J. Miller.

Observations of Eros at the Opposition 1930–31. By H. Spencer Jones, Chairman, Solar Parallax Commission, I.A.U.

The approaching opposition of Eros will be widely observed for the determination of the solar parallax, the mass of the moon and related constants. The following remarks are mainly for the general guidance of those who are participating in the photographic observations. In *Ast. Nach.*, No. 5680, directions for the guidance of those undertaking micrometric observations are given by Professors Witt and Kopff.

The motion of Eros near opposition is rapid and mainly in declination; the maximum motion amounts to nearly 3″ per minute. The

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images of either the comparison stars or of Eros must therefore be allowed to trail. Guiding on Eros would have the advantage that the greater error of bisection of a trailed image would be reduced by the number of comparison stars available, but is only possible if the telescope is provided with means for accurate guiding in declination. Where conditions permit, observers should make trial of both methods and use whichever method proves the more convenient and accurate. An alternative method is to guide on Eros in right ascension only; the image of Eros then would be trailed in the declination direction, and the images of the stars would be trailed slightly in the right ascension direction. Such trails may prove more suitable for accurate bisection than oblique trails. The path of Eros lies in a region which is generally poor in stars; allowing the stars to trail will restrict to some extent the comparison stars available, and this must be taken into consideration in deciding which method to adopt.

The length of exposure time should be made as short as possible consistent with securing good, measurable images. Observers are recommended to make trials with plates of different speeds: the shorter trails obtained with faster plates as a consequence of the shorter exposures may more than outweigh the disadvantage of coarser grain, and increased accuracy in bisection may result.

Near opposition, Eros is much brighter than the available comparison stars. Its brightness should therefore be reduced by means of a rotating sector, so that the densities of the images of Eros and the comparison stars are reduced to approximate equality; bisection errors will thereby be reduced and guiding errors eliminated. With the same instrument, the brightness reduction required will depend upon whether the telescope is guided upon Eros or the stars. The brightness of Eros is variable in a period of about five hours, during which time there are two maxima and two minima of light. The range in brightness is not constant but may be as large as 1^{m}: observers should be on the look-out for such variations and employ the appropriate brightness reduction.

The times of beginning and ending each exposure must be determined with accuracy, in view of the rapid motion of the asteroid. If conditions are not uniform, owing to drifting thin cloud or to an unevenly veiled sky, it would be better not to secure observations, as an appreciable error in the mean time of exposure may be caused.

The parallax of Eros has its maximum value ($50''\cdot 3$) about the end of January 1931. Opposition occurs on 17th February. For the derivation of the solar parallax, observations could be restricted to the period when the parallax of Eros is large. For the derivation of the mass of the Moon, however, it is desirable that the observations should be extended over a longer period. Observations for this purpose are required near the times when the lunar equation has its extreme values. In the discussion of the observations secured at the opposition of 1901, it was found that the errors of the ephemeris of Eros could not be represented by an expansion in powers of the time. In order, therefore, to disentangle the errors of the ephemeris from the errors of the lunar equation, arising from the use of an incorrect mass of the Moon, it was

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1930MNRAS..90..724S

necessary to derive the errors of the ephemeris from observations obtained at the times when the lunar equation had its zero value. From the results the errors at the times when the lunar equation was not zero were derived by interpolation. It is therefore desirable, in order to provide adequate material for the separation of ephemeris errors from errors in the lunar equation, that observations should be obtained not only at times when the lunar equation has its extreme values, but also at the times when it is zero. The lunar equation in R.A. is proportional, *inter alia*, to $\sin(\alpha - \alpha_{☾})$, where α denotes the R.A. of Eros, and $\alpha_{☾}$ the R.A. of the Moon. Observations should therefore be obtained near the times when $\alpha - \alpha_{☾} = 0h, 6h, 12h$, and $18h$, and they should be extended over as many periods of the lunar equation as possible. Observatories which are engaged only in observations by the diurnal method could usefully obtain several plates, with Eros on or near the meridian, at times when the lunar equation is zero or has its extreme values.

The solar parallax can be derived from three types of observation :

(1) From observations taken at a single observatory at large east and west hour angles, *i.e.* evening and morning. Observations should be restricted to altitudes greater than 30° in order to minimise the effects of atmospheric dispersion.

(2) From observations secured simultaneously at two observatories in approximately the same latitude but differing several hours in longitude, *e.g.* near the meridian at the eastern observatory and at large easterly hour angle at the western observatory.

(3) From observations secured simultaneously at two observatories in approximately the same longitude but differing as widely as possible in latitude (*i.e.* a northern and a southern observatory).

Methods (2) and (3) have the advantage of being practically independent of errors in the comparison star-places, as the same comparison stars would be used at the two observatories, and of errors in the ephemeris of Eros. Method (1) is not free from the effects of errors of the star-places, since the motion of Eros is so rapid that the same comparison stars cannot be used for measurement of evening and morning plates secured on the same night. Observations by method (1) can be continued, however, for a longer period than those by methods (2) and (3). Several observatories are co-operating in observations by method (3), and there may be some co-operation by method (2). Observatories desiring to co-operate in observations by methods (2) and (3) should arrange details mutually.

The plates secured by methods (1) and (2) would be measured in right ascension, those by method (3) in declination. Observations by method (3) are possible only during the period when Eros is moving rapidly in declination. The trailed images, whether of Eros or of the stars, can be bisected less accurately when measuring in the declination direction than when measuring in the right ascension direction. In order to minimise errors of bisection, it is suggested that observations by method (3) should be made as follows: Expose for one-quarter of the period required to give good measurable images of the comparison stars, the

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1930MNRAS..90..724S

telescope being guided on the stars or on Eros in R.A. only (*e.g.* if 2^m exposure is required for comparison stars of $10^m{\cdot}5$–$11^m{\cdot}0$, the exposure would be 30^s). Then close the shutter for a short period (*e.g.* for 2^m). Then give a further exposure of the same duration, followed by another interval, and so on. When four exposures have been given, four short trailed images of Eros will be obtained which are capable of accurate bisection, and the total exposure on the comparison stars will be such as to give good, measurable images. A rotating-sector should be employed, if necessary, with opening adjusted to make the images of Eros and of the comparison stars comparable in density. The measurement being in declination, guiding errors arising from the exposures of Eros and the stars not being synchronous, do not enter.

The primary reference stars, selected by Professor Kopff, are listed in *Ast. Nach.*, Nos. 5375, 5403. The definitive catalogue of the positions of these stars is now in course of preparation at the Astronomisches Recheninstitut. These positions should be used as the basis for all the photographic reductions. For plates obtained with telescopes of the Carte-du-Ciel type, the primary reference stars can be employed as comparison stars. For plates covering smaller fields, obtained with instruments of longer focal length, fainter comparison stars (say of $10^m{\cdot}5$–$11^m{\cdot}0$) must be used. The positions of such stars must be derived photographically, using the primary reference stars as a basis. Arrangements will be made to supply positions of reference stars to any observatory which has not the means to connect the secondary reference stars employed with the adjacent primary reference stars.

With a view to minimising the effects of differential atmospheric dispersion, it is desirable that stars of extreme colour (types B and K5 to M) should not be used as reference stars. The spectral types of the primary reference stars, which are not given in the Henry Draper Catalogue, are listed in *Harvard Bulletin*, No. 871. It is hoped that a survey of secondary reference stars ($10^m{\cdot}5$–$11^m{\cdot}0$) may be made, and the stars of extreme colour listed for exclusion.

Observatories with meridian instruments are requested to obtain as many observations as possible of Eros at meridian transit, in order to control the ephemeris. Several of the primary reference stars should be observed on each night that Eros is observed in order to reduce the observed positions of Eros to the basis of the system of the primary reference stars. In order to eliminate magnitude-error, Eros should preferably be observed through a screen of such density that the magnitude of Eros is brought to equality with the mean magnitude of the primary reference stars.

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1930MNRAS..90..724S

The Orbit of Neptune. By J. Jackson, M.A., D.Sc.

(Communicated by the Astronomer Royal.)

Introduction and Summary.—Leverrier's orbit of Neptune was based on two observations by Lalande in 1795 and on a regular series of observations from the time of the discovery of the planet in 1846 to 1873. When this orbit was replaced by Newcomb's in 1904 the planet had fallen about 5″ behind the predicted place. Newcomb used observations till 1898, but his orbit left a residual of 2″ in 1795. Since 1904 the planet has gradually fallen behind Newcomb's prediction, the discordance now amounting to about 3″. The question arises as to how far it is possible to reconcile the observations and theory. This paper shows that by a simple change of the elements not only the modern observations but also Lalande's observations can be satisfied very closely indeed. As only 30 years have to elapse before Neptune returns to the position occupied in 1795, the shape of the orbit should now be satisfactorily known unless, indeed, Lalande's observations were seriously wrong, which can hardly be the case as the two observations show the theoretical motion to a fraction of a second.

Tabular Positions.—In the introduction to his theory Newcomb gives the residuals in longitude and parallax at intervals of 4 years to 1896. The *Nautical Almanac* adopted Newcomb's tables in 1904, and from that date onwards a direct comparison is possible between the observations and theory. To fill the gap, the heliocentric places of Neptune for the first day of each year from 1896 to 1904 were computed. The following table shows the corrections required to reduce Leverrier's tables to Newcomb's.

Newcomb's–Leverrier's Tables.

(January 1 of each year. *N.A.* positions used for Leverrier.)

	$\Delta\lambda$.	$\Delta\beta$.	7th Decimal of log r.
	″	″	
1896	−2·18	−1·78	−51
1897	−2·31	−1·85	−45
1898	−2·76	−1·89	−33
1899	−3·37	−2·02	−26
1900	−3·88	−2·08	−31
1901	−4·33	−2·16	−40
1902	−4·67	−2·15	−51
1903	−4·90	−2·23	−52
1904	−5·06	−2·35	−65

It should be noted that the heliocentric longitude given in the *N.A.* for 1896 refers to the true equinox, but for 1897 and later to the

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