17. COMMISSION DU MOUVEMENT ET DE LA FIGURE DE LA LUNE

Report of Meeting, 17 August 1961

PRESIDENT: K. Koziel.

SECRETARY: Flora M. McBain Sadler.

The *Draft Report* was approved without modification.

The President read the following additional report received from Pulkovo Observatory:

'The photography of the Moon by the Markowitz method has been continued. An instrument for the automatic photo-electric measurement of these photographs has been constructed by N. F. Bystrov and used with great effect. A method was proposed for obtaining the figure of the lunar disk from photographs taken at full moon (or during an annular solar eclipse). H. I. Potter and N. F. Bystrov have found from the measurements of photographs taken on 1958 September 27-28 a value for the flattening of 1/1200, the major axis of the ellipse being directed towards the north-west in position angle 324°.'

The President proposed that the Organizing Committee for Commission 17 should consist of himself as President of the Commission, Th. Weimer as Vice-President, A. A. Nefediev and C. B. Watts; and this proposal was unanimously adopted.

He also reported that the Organizing Committees of Commissions 16 and 17—both interested in the problems of the Moon—agreed in a joint session to form several special-purpose committees consisting of the members of both commissions and of other interested astronomers. Of these the following two should operate as a part of Commission 17:

Selenodesy. Chairman: K. KOZIEL; Members: D. W. Arthur, M. S. Hunt, Z. Kopal, A. A. Mikhailov, H. I. Potter, G. Schrutka-Rechtenstamm, Th. Weimer.

Internal Structure of the Moon. Chairman: Z. KOPAL; Members: Harrison Brown, K. Koziel, G. P. Kuiper, B. J. Levin, G. J. P. MacDonald, E. M. Shoemaker, H. C. Urey.

The purpose of these committees is to provide certain specific information, the need for which has become evident at recent international meetings—such as the conference on the problems of lunar topography at Bagnères-de-Bigorre in April 1960, or the IAU Symposium No. 14 held at Leningrad in December of the same year. The creation of these committees was approved without dissention. The President then called on Professor Kopal to outline some of the proposed tasks.

Z. Kopal gave a brief account of the proceedings of a conference on current problems of selenodesy and topography of the Moon, which was held at the Observatoire du Pic-du-Midi between 19 and 23 April 1960. Dr Jean Rösch, Director of the Observatoire du Pic-du-Midi, acted as chairman of a gathering which included Drs Camichel, Campen, Carder, Dollfus, Hunt, Kearns, Kopal, Koziel, Rackham, Ring, Schrutka-Rechtenstamm and Weimer.

One of the main aims of this conference (the Proceedings of which, edited by Z. Kopal and E. B. Finlay, should shortly be available for distribution as an *Astronomical Contribution from the University of Manchester*, Series III, No. 90) has been to discuss the ways in which the existing systems of three-dimensional co-ordinates on the surface of the Moon could be improved in the near future. As a result of extensive discussions held on this occasion it was recommended:

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(*a*) To reduce anew all past heliometric observations of the crater Mösting A with the aid of an electronic computer, in order to improve our present knowledge of the libration constants of the Moon. This task is to be undertaken shortly by Professor Koziel at the University of Manchester in England.

(*b*) To select a system of 100-200 lunar control points of second order, defined by the position of small craters (5-10 km in diameter) which are sufficiently shallow and geometrically well-defined to enable us to measure accurately their positions; and to employ the lunar plates taken with the Markowitz cameras during the IGY to determine the positions of such craters with respect to a fundamental frame of reference as represented by the neighbouring stars. This problem has since been under active investigation by Drs Weimer and Hunt.

(*c*) To use the shadows cast by the irregularities of the lunar surface in oblique illumination by the Sun for determination of relative heights above the osculating surface of the local mean selenoid (as defined by three or more adjacent points of second order). Extensive work along these lines has been in progress at the University of Manchester since 1958 (Professor Kopal and Mr Rackham), using photographic material secured at the Observatoire du Pic-du-Midi; and a comprehensive mathematical analysis of the problem is being published by Kopal in Chapter VII of the forthcoming compendium on *The Moon* (Academic Press, London and New York, 1961).

An interesting discussion followed in which Atkinson, Mikhailov, Markowitz, Heyden, Gold, Dollfus and B. C. Murray took part. It was emphasised that it was necessary to have measures of the control points both with respect to the Moon's limb and with respect to the stars. There were suggestions that it might be desirable to build large instruments specially for the purpose and, taking a long-term view, suggestions were made as to the use of artificial satellites for solving some of the problems involved.

Sir Harold Jeffreys gave a short account of his recent work on "The Figure of the Moon," a full account of which is published in *M.N.*, **122**, 421, 1961. In reply to a question from Eckert he confirmed that he had included Brown's additional terms in his work.

R. G. Hall presented a report on the Moon-Position Photographic Programme of the U.S. Naval Observatory. A total of 1118 plates taken at Washington from 1952 June to 1961 July 1 has been reduced. In connection with the IGY programme beginning 1957 July 1, other plates from various observatories have been measured as follows: U.S. Naval Observatory 1048, Cape Observatory 471, Paris Observatory 213, Royal Greenwich Observatory 116. In addition, plates have been received from Curacao, Hawaii, Helsinki, Mount Stromlo, Naini Tal, Ottawa, Perth, San Diego, San Fernando, Sao Paulo, Tokyo and Uppsala.

The results show strong systematic effects which are probably due to the fact that the shape of the Moon departs appreciably from sphericity. It is expected that these effects will be reduced when the limb corrections, being derived by Watts, are applied.

In a joint experiment with Essen and Parry of the National Physical Laboratory, Teddington, a value of 9 192 631 770 ± 20 cycles per second of E.T. was derived for the frequency of caesium, based on Moon observations made at the U.S. Naval Observatory from 1954·0 to 1958·5. A re-determination based on observations from 1955·5 to 1960·5 gives the same value within the errors of observation.

S. Arend fait part de ce que J. Dommanget, à l'Observatoire royal de Belgique, a tenté de déterminer la forme géométrique moyenne de demi-profils lunaires. Se servant de deux clichés obtenus en 1924, au moyen d'un héliographe par E. Delporte, et de trois clichés, pris en 1960 par lui-même à l'aide de l'équatorial de 45 cm d'Uccle (f = 7 m), il a représenté chaque fois une trentaine de mesures faites sur le pourtour de chaque demi-profil lunaire par

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une ellipse en sorte que la somme des carrés des distances à l'ellipse des points mesurés soit minimale. Il a tenu compte de la réfraction différentielle. L'excentricité des ellipses et l'orientation des axes de celles-ci par rapport à la direction nord de l'axe de rotation de la Lune, sont les suivantes:

Date	Observateur	Profil	Excentricité	Angle au pôle
14 février 1924	Delporte	W	0·09	$-17^{\circ}\cdot7$
12 mars 1924	*id.*	W	0·08	$-16^{\circ}\cdot5$
17 février 1960	Dommanget	E	0·11	$-5^{\circ}\cdot3$
6 mars 1960	*id.*	W	0·10	$-32^{\circ}\cdot6$
3 mai 1960	*id.*	W	0·15	$-73^{\circ}\cdot4$

La moyenne des excentricités se monte à 0·106 ± 0·024 (e.m.), ce qui correspond à un aplatissement de l'ordre de 1:180. Il y a surtout lieu de retenir que les grands axes sont tous situés dans le même quadrant, qui est celui où se trouve le cirque Tycho.

Weimer drew attention to the large discrepancy between this result and the value of 1/1200 obtained by Potter at Pulkovo. In reply to Buchar, Arend said that differential refraction had been applied. In the subsequent discussion, in which Dollfus, C. A. Murray, Mikhailov, Weimer and Markowitz took part, it was suggested that more plates at full moon or during annular eclipses were required, and that the separation of the east and west limb observations weakened the solution.

S. Arend signale encore qu'à l'Observatoire royal de Belgique, J. Dommanget et lui-même, ont été amenés à reconsidérer le problème de la détermination précise des instants des contacts extérieurs des éclipses de Soleil. A l'occasion des réductions des observations des éclipses du 1959 octobre 2 et du 1961 février 15, faites à Uccle par la méthode des cordes, il est apparu une similitude très nette entre les résidus trouvés par chacun des deux observateurs. J. Dommanget a montré que ceux-ci s'expliquent très bien par la présence des irrégularités du profil lunaire et que celles-ci peuvent affecter sensiblement, *de façon systématique*, les instants conclus pour les instants des contacts. S. Arend, considérant une éclipse fictive dans laquelle les effets des échancrures et des aspérités du bord lunaire furent numériquement introduits, a examiné diverses méthodes de calcul susceptibles de mieux moyenniser ces effets de façon à obtenir des résultats précis. Les deux auteurs ont été amenés à mettre au point des méthodes qu'ils espèrent utiliser avec succès au cours des prochaines éclipses.

J. Witkowski reported on a new method developed at Poznań Observatory for determining the Moon's physical libration. The basic idea is to determine the Moon's rotation relative to the stars by measuring the shadows of the lunar mountains in the vicinity of the terminator. The length of the shadow and its azimuth determine the selenographic co-ordinates of a mountain's summit for the time of observation, as the Sun's selenocentric co-ordinates are known. The Moon's physical libration may be derived from the differences in the selenographic co-ordinates thus obtained for different times of observation. In practice allowance has to be made for the fact that the shadows are distorted by the uneven surface of the Moon and that the azimuths are difficult to determine with sufficient accuracy. It is most convenient and effective to measure the shadows for great zenith distances of the Sun, when the length of the shadow is changing rapidly.

It is estimated that there are about 1000 suitable mountains on the Moon to which this method could usefully be applied. The method has the advantage of being free from errors due to irregularities of the Moon's limb. The details and necessary formulae are at present being developed, and a paper by W. Szulakowski giving full details should appear in 1962 in *Acta Astronomica.*

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