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Photoelectric Photometry of the Total Lunar Eclipse of September 16, 1978

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The total lunar eclipse of September 16, 1978 was observed photoelectrically at the Kleť Observatory. From photometric measurements the densities of the umbra and of the penumbra in the spectral region *V* were obtained.

Фотоэлектрическая фотометрия полного лунного затмения 16-го сентября 1978 г. — Лунное затмение наблюдалось в обсерватории Клеть. Привдятся плотности тени и полутени в спектралной области V из фотометрических измерений.

Úplné zatmění měsíce 16. září 1978 bylo fotoelektricky měřeno na hvězdárně na Kleti. Z fotometrických měření byly určeny hustoty stínu a polostínu ve spektrální oblasti *V*.

1. Introduction

The observation conditions during the total lunar eclipse of September 16, 1978 were not too favourable in Czechoslovakia. The Moon entered the penumbra at 16^h21^m (U. T.), whereas the Sun sets at 17^h05^m and the Moon rises at 17^h01^m (Kleť Observatory). The Moon entering umbra at 17^h20^m was only 2° over the horizon, at the beginning of the total eclipse (18^h24^m) it was 13° over the horizon. From this reason only the second part of the eclipse was observable. The photoelectric observation was possible as late as 19^h09^m (zenith distance of the Moon 70°), i.e. roughly from the middle of the eclipse (19^h04^m). The zenith distance of the Moon at the end of the total eclipse (19^h44^m) was 66°, at the time in which the Moon leaved umbra (20^h48^m) it was 58°, and at the time at which the Moon leaved penumbra (21^h48^m) it was 53°.

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2. Brightness of the Eclipse

The eclipse was observed visually by some observers in Czechoslovakia, who estimated its brightness L in the well-known Danjon's five-point scale (Table 1). The

Table 1.

No.	Observer, Observatory/Station	L
1	E. Belda and A. Houška, Turnov	2
2	J. Bouška, Kleť	2.5
3	P. Duchoň, Plzeň	2
4	M. Dujnič, Rimavská Sobota	2
5	L. Kováč and V. Kováčová, Sereď	3
6	Z. Machovský, Domoradovice	2.5
7	B. Málek, H. Bludovice	2
8	M. Petr, H. Bludovice	2
9	A. Slatinský, H. Bludovice	3
10	V. Toman, H. Bludovice	2.5
11	V. Wagner, H. Bludovice	3

Table 2.

U. T.	D	U. T.	D	U. T.	D
$19^h09.3^m$	4.95	$20^h16.3^m$	2.37	$20^h36.0^m$	0.06
12.0	4.83	18.9	2.21	38.0	0.05
15.5	5.05*	19.5	2.11	41.0	0.07
16.5	4.61	20.0	2.07	45.0	0.07
20.5	4.61	20.5	2.04	49.0	0.04
26.0	4.46	22.9	1.79	54.0	0.01
32.0	4.49*	23.4	1.57	56.0	0.01
34.5	4.27*	23.9	1.47	59.0	0.00
40.0	3.87	24.9	1.27*	$21^h04.0$	0.00
45.4	3.62	25.9	1.02	05.0	0.00
50.7	3.25	26.5	0.92	05.5	0.00
53.3	3.10	27.0	0.90	08.7	0.00
57.3	2.80	28.5	0.64	15.5	0.00
$20^h01.3$	2.66	29.5	0.52	21.7	0.00
03.3	2.53	30.0	0.38	27.5	0.00
05.5	2.52	31.3	0.31	34.5	0.00
08.0	2.46	32.0	0.25	40.0	0.00
10.0	2.48	33.0	0.18	45.7	0.00
12.5	2.52*	33.5	0.13	50.0	0.00
14.0	2.50*	35.0	0.08	51.0	0.00

mean value of the brightness of this eclipse was $\bar{L} = 2.4 \pm 0.1$, which is in good agreement with the mean value of the brightness of 45 lunar eclipses observed by different observers between the years 1802–1975 ($\bar{L} = 2.40$; Bouška, to appear).

3. Photoelectric Observation

The eclipse was observed at the Kleť Observatory with the 250-mm Zeiss refractor ($f = 3100$ mm). A photoelectric photometer with the EMI 6094 photomultiplier was used, the diameter of the diaphragm was 104″. The observations in the instrumental

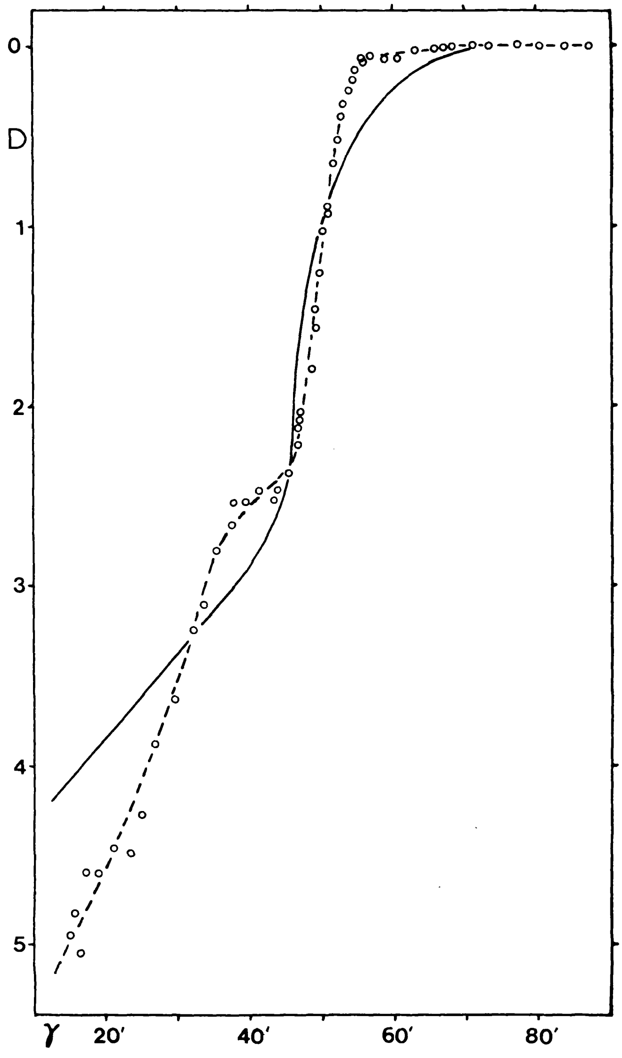

Fig. 1.

V-colour were reduced for the spectral region V. All the observations were corrected for the atmospheric extinction. During the observation period the air mass varied within $3.00 > M > 1.66$.

Brightness of an area on the lunar surface was measured, which was situated in the Mare Nubium, not far from the crater Nicollet. Between $19^h09^m - 21^h51^m$ (U. T.) 60 measurements were obtained from which the densities D of the Earth's shadow were computed (Table 2).

The weather conditions were very favourable during the photometric observation; only some of the measurements were probably influenced by faint high clouds. These observations are denoted in Tab. 2 by an asterisk.

The densities D of the shadow are shown in Fig. 1 as function of the distance γ from the centre of the shadow. The theoretical densities of the shadow for the Moon's parallax $\pi = 60'$ and for the wavelength 540 nm [1] are also shown in this figure. The theoretical densities are represented in this figure by the thick curve, the observed densities by circles and by the dotted curve.

4. Discussion of Results

Table 3 shows the differences ΔD between the observed and computed densities of the shadow for different distances γ from the centre of the shadow. M_0 is the corresponding value of the mean air mass. The theoretical densities of the shadow were computed under the assumption of the ideal (pure) Earth's atmosphere using the value of the absorption coefficient $A_0 = 0.043$. It is evident that the real absorption

Table 3.

γ	ΔD	M_0	γ	ΔD	M_0
10′	+1.10	46	55′	−0.30	2.5
20′	+0.80	32	60′	−0.20	1.0
30′	+0.25	21	65′	−0.10	0.5
40′	−0.20	11	70′	0.00	0.5
50′	0.00	5			

coefficient must be larger than the used A_0 one. The value of the real absorption coefficient A may be obtained from the relation [3]

$$\Delta D = M_0(A - A_0) .$$

The real absorption coefficient of the troposphere ($h < 12$ km), determined from the values ΔD and M_0, obtained from the lunar eclipse of September 16, 1978 is $A = 0.063$. This value is somewhat smaller in comparison with the absorption coefficients found in some previous eclipses (see e.g. [2], [3]). The densities of the central parts of the shadow may be moreover influenced by the clouds in the lower troposphere around the Earth's terminator. The Earth's terminator at the beginning of the observation (full curves) and the end of the observation (dotted curves) is shown in Fig. 2.

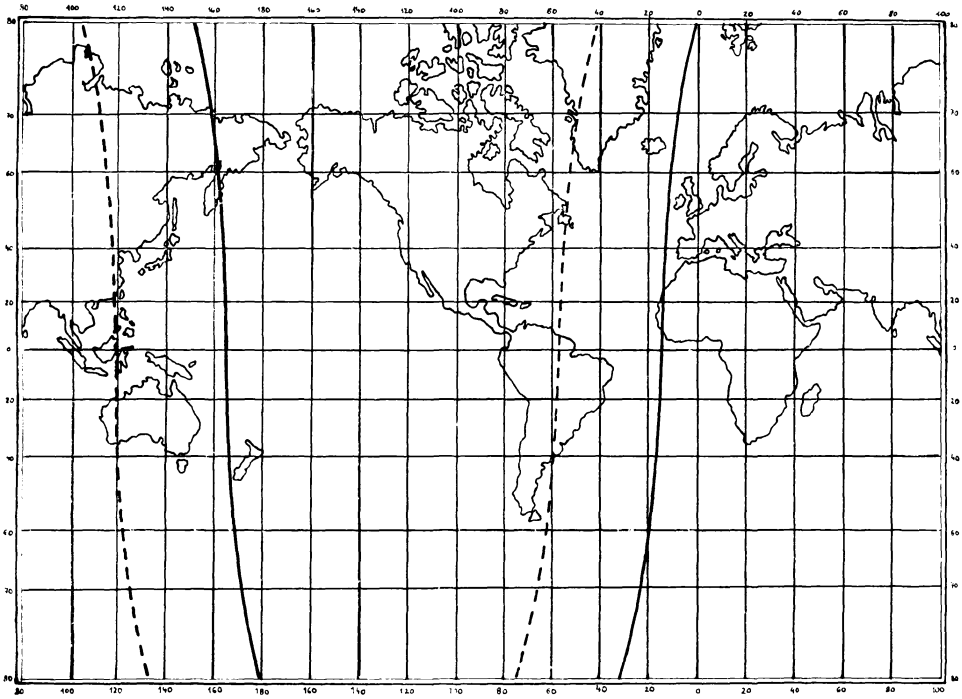

Fig. 2.

Interesting is the light excess in the shadow in the distances $\gamma \sim (33' \div 45')$. It shows that the real absorption coefficient for the Earth's atmospheric layers in the heights between 15–30 kilometers was very small, somewhat smaller than its adopted theoretical value. This fact may be in connection with anomalous conditions in the atmospheric ozone layer.

Fig. 1 shows moreover a brightening of the penumbra in the distances $\gamma \sim \sim (52' \div 67')$. Such a light excess in the penumbra was observed during some previous eclipses and it was explained by supposed luminiscence of the lunar surface [1]. On the contrary, the authors did not observe such a light excess during the photometrically measured lunar eclipses of June 24–25, 1964 [2], September 25, 1969 [4] and August 6, 1971 [3]. It is not excluded that this light excess in the penumbra has its source in the Earth's atmosphere.

However, there exists another explanation of the observed light excess in the penumbra. From the analysis of the lunar samples brought by Apollo and Luna missiles it is known that the luminiscence is not a general property of the whole lunar surface. On the other hand, it may be not excluded that in some regions of the Moon's surface the luminiscence of the lunar regolith may be observed. One of such regions is probably situated in the measured area in Mare Nubium. The photometric measuring of this region during the next lunar eclipses may be very interesting.

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