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Enlargement of the Earth's Shadow During the Lunar Eclipse of July 26, 1972

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From 29 observed entrances and 33 exits from the umbral shadow collected by Ashbrook the enlargement of the Earth's shadow 1/66 was found.

The partial lunar eclipse of July 26, 1972, was observable in the western hemisphere. The contacts of lunar features with the umbral shadow, observed by some observers in the U.S.A., were collected by J. Ashbrook [1]. The observational material of this eclipse was not so numerous as that of the formerly observed eclipses in the U.S.A. During the last eclipse there were observed only 29 entrances of 13 features into the shadow and 33 exits of 13 features from the shadow. From the times of contacts obtained by more than one observer Ashbrook computed the mean errors of the contacts which are between ± 0.4 and ± 3.4 min.

From the observed contacts collected by Ashbrook the present author computed the enlargement of the Earth's shadow. Kozik's [2] method was used and the rectangular coordinates of lunar features were taken from catalogues by Bouška et al. [3] and Kozik [4]. The computation was made on the MINSK-22 computer and the coordinates of the Sun and the Moon and the values of lunar parallax were taken from the Astronomical Ephemeris for the year 1972. The difference ET — — UT = 42.6^s was adopted.

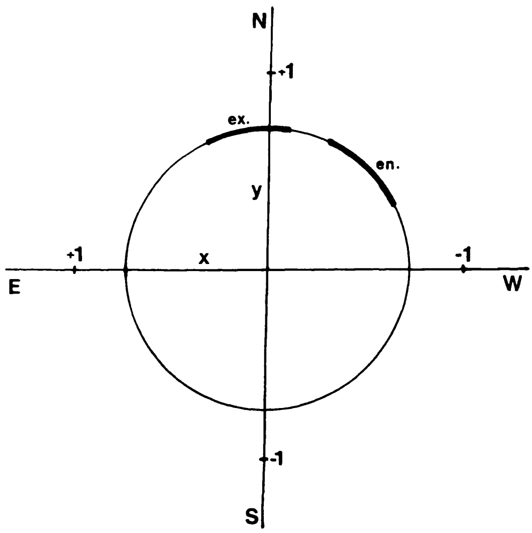

Fig. 1.

Table 1 contains the names of lunar features, the Universal Time

Table 1.

Feature	*U T*	*N*	ψ	*r*
Entrances				
Vitello	$6^h09.2^m$	1	$+30.2°$ W	0.7385
Grimaldi	11.6 ± 1.0^m	3	$+44.1 \pm 0.6$ W	0.7343 ∓ 0.0040
Riccioli	13.0 ± 0.6	4	$+46.2 \pm 0.4$ W	0.7316 ∓ 0.0022
Gassendi	14.0	1	$+37.1$ W	0.7359
Tycho	17.2 ± 0.5	7	$+26.1 \pm 0.2$ W	0.7385 ∓ 0.0031
Pitatus	21.4	1	$+32.1$ W	0.7368
Encke	39.1	1	$+56.9$ W	0.7378
Kepler	51.3 ± 0.7	5	$+65.9 \pm 0.5$ W	0.7344 ∓ 0.0020
Goclenius	7 13.0	1	$+52.3$ W	0.7293
Langrenus	19.4 ± 0.4	2	$+53.9 \pm 0.3$ W	0.7305 ∓ 0.0010
Messier	29.5 ± 1.3	3	$+63.7 \pm 0.8$ W	0.7360 ∓ 0.0015
Exits				
Kepler	7 06.7 ± 0.5	4	$+76.6 \pm 0.4$ W	0.7352 ± 0.0004
Encke	19.6	1	$+85.0$ W	0.7382
Riccioli	22.2 ± 0.5	4	$+84.2 \mp 0.3$ E	0.7333 ± 0.0019
Grimaldi	25.8 ± 0.5	5	$+82.5 \mp 0.3$ E	0.7331 ± 0.0020
Censorinus	41.2 ± 1.0	2	$+75.8 \pm 0.7$ W	0.7337 ± 0.0007
Messier	49.6 ± 3.4	2	$+77.7 \pm 2.3$ W	0.7350 ± 0.0035
Vitello	56.5	1	$+69.0$ E	0.7316
Campanus	58.2	1	$+70.7$ E	0.7322
Mercator	59.8	1	$+69.5$ E	0.7308
Pitatus	8 04.8	1	$+70.6$ E	0.7331
Langrenus	08.8 ± 1.0	4	$+88.8 \pm 0.7$ W	0.7329 ± 0.0027
Tycho	13.9 ± 0.6	7	$+64.5 \mp 0.4$ E	0.7352 ± 0.0037

of the observed contacts with their mean errors, the number N of observed contacts, the position angles ψ and the radii r of the shadow, both with their mean errors. The mean values of the mean errors in radius are ± 0.0023 for entrances and ± 0.0021 for exits, the mean values of mean errors in position angle are $\pm 0.5°$ for entrances and $\pm 0.4°$ for exits, respectively. From the observational material 3 contacts were omitted. The entrance of Campanus was observed evidently too early (by about 1 min.), the entrance of Colombo was timed too late (by about 7 min.) and the exit of Capuanus was observed too early (by about 3 min.).

The theoretical values of the radius of the shadow were computed from the geometrical conditions using the formula

$$r_c = 0.7255 - 0.0030 \sin^2 \psi. \tag{1}$$

From differences between the observed and the computed radii of entrances the following mean value of the enlargement of the shadow was determined

$$\frac{r_o - r_c}{r_o} = 1.51\ \% = 1/66.$$

The entrances were observed at position angles between $+26°$ and $+66°$ W. The enlargement of the shadow computed from the exits is

$$1.52\ \% = 1/66;$$

the exits were observed at position angles between $+64°$ E and $+76°$ W. Fig. 1 shows the observed arches of the shadow where the entrances (en.) and the exits (ex.) were observed.

The observational material is, however, not usable for an exact determination of the form of the shadow. It seems that the form of the shadow may be represented by the formula

$$r_o = 0.7372 - 0.0037 \sin^2\psi, \tag{2}$$

but especially the second term in this formula is not sufficiently accurate. Comparing formulae (1) and (2) it is evident that the observed flattening of the shadow was nearly the same as the computed one.

The enlargement of the Earth's shadow during the lunar eclipse of July 26, 1972, was considerably smaller than usually (i.e. $\approx 2\ \%$). Also during the total lunar eclipse of January 30, 1972, Ashbrook [5] found a relatively small value of the enlargement of the shadow. He collected 715 individually observed contacts (420 entrances and 295 exits) of 15 lunar features. From the times of entrances (between position angles $-35°$ and $+4°$ E) the enlargement was 1.69 %, from the times of exits (between $-78°$ and $-38°$ W) the enlargement was 1.68 %, both values with the mean error ± 0.06 %. From these results it is evident that at the end of January and at the end of July, 1972, the transparency of the lower parts of the Earth's upper atmosphere was very high and that the density of the atmospheric dust layer at the heights 30—70 km was extraordinarily low.

During the two mentioned 1972 lunar eclipses, of January 30 and July 26, no asymmetry of the Earth's shadow was found. There was no difference between the enlargement of the eastern and the western part of the shadow which was ascertained during some previously observed eclipses.

The lunar eclipse of January 30, 1972, was also observed by Golubjev and Lookashenko [6]. These authors found no asymmetry of the shadow, either, but they derived a much larger enlargement of the shadow ($2.27\ \% = 1/44$) than Ashbrook did. They observed 20 contacts only, from which 10 entrances and 8 exits were used for computation. This observational material seems to be not sufficient enough for an accurate determination of the enlargement and especially of the flattening of the shadow.

References

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