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CORRECTION TO THE ARGUMENT OF WATTS' MOON LIMB CHARTS OBTAINED FROM THE LUNAR OCCULTATION OF MARS IN 1986†

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Abstract

Clear silhouettes of the Moon's limb with the planet for a background is seen on the photographs of the lunar occultation of Mars in 1986 taken at Bisei Hydrographic Observatory. Analyzing them , the correction to one of the arguments, position angle, of the Watts' Moon limb charts is obtained as −0.11°.

Key words : Lunar occultation, Moon's limb profile

1. Introduction

Correction for the irregularity of the Moon's limb is important in reductions of lunar occultation timing data and usually the Moon's limb profile charts by Watts (1963) is used for this purpose. It is reported, however, that one of the arguments, position angle from the central meridian of the Moon, for entry to the charts has an error, i.e. about 0.2° should be added to the true angle at every point on the limb when consulting the charts(e.g. Appleby and Morrison, 1983). Since this considerably affects on the result of reductions of lunar occultation observations, it is necessary to verify the fact by as many means as possible.

Some photographs of the lunar occultation of Mars were taken at Bisei Hydrographic Observatory on July 20, 1986 (Kenmotsu et al., 1986). They give clear profiles of the Moon's limb in silhouette with Mars as a background. Since the positions of the Moon and Mars are known with the accuracy of 0.1", the position angle for each point on the profile shown in silhouette could be determined with the accuracy of 0.1"／(semi-diameter of the Moon) or 0.006°. Using this a determination of the amount of the correction to the position angle of the Watts' charts is made.

The present article gives a brief outline of the process and the results of the reduction of this photographic data.

2. Configuration of the Mars and the Moon's limb at the time of phenomenon

For some instants during the phenomenon of the occultation, the topocentric position of the Moon and Mars are computed based on the Ephemeris. The rigorous formulae for the computation of the topocentric positions are employed. In the computation the following correction is applied to the Moon's center obtained from the Ephemeris :

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$\triangle\lambda = +0.38''$, $\triangle\beta = -0.20''$.

These are mainly due to the difference between the figure- and mass-centers of the Moon and found from the observations of occultations of stars made by the Hydrographic Department of Japan (1989).

Then the position angle χ and distance σ of the center of Mars with respect to the Moon's center as seen from the observation site are computed using the following formulae :

$$\sin\sigma \sin\chi = \cos\delta_{\sigma} \sin(\alpha_{\sigma} - \alpha_{\leftmoon}),$$

$$\sin\sigma \cos\chi = \sin\delta_{\sigma} \cos\delta_{\leftmoon} - \cos\delta_{\sigma} \sin\delta_{\leftmoon} \cos(\alpha_{\sigma} - \alpha_{\leftmoon}),$$

$$\cos\sigma = \sin\delta_{\sigma} \sin\delta_{\leftmoon} + \cos\delta_{\sigma} \cos\delta_{\leftmoon} \cos(\alpha_{\sigma} - \alpha_{\leftmoon}),$$

weher $\alpha_{\leftmoon}$, α_{σ}, $\delta_{\leftmoon}$ and δ_{σ} are the topocentric right ascensions and declinations of the Moon and Mars, respectively.

The angular distance from the center to the mean surface of the Moon $s_{\leftmoon}$ or the topocentric semi-diameter of the Moon is given by

$$s_{\leftmoon} = \sin^{-1}(k/r_{\leftmoon}),$$

where k(=0.2725026) is the radius of the Moon in unit of the equatorial radius of the Earth and $r_{\leftmoon}$ is the topocentric distance of the Moon. Semi-diameter of Mars s_{δ} is also taken from the Ephemeris.

All the computed values at an epoch near the middle of the phenomenon adopted for comparison with a photograph are shown in Table 1.

Table 1. Topocentric positions etc. of the Moon and Mars

time(UTC)		α	δ	r	χ	σ	s
1986 July 20							
h m s		h m s	° ′ ″	a_e	°	″	″
11 39 08	Moon	19 05 48.324	−28 23 30.01	56.340989	96.83	1000.29	997.64
	Mars	19 07 03.612	−28 25 27.76	9492.493			11.56

3. Comparison with the photograph and the obtained correction

Then an enlarged map of Mars and that portion of the Moon's limb where the planet dives into the Moon is drawn for the adopted epoch (Figure 1) and it is compared with the photograph taken at the same instant (Figure 2). The argument along the Moon's limb in Figure 1 is

$$\Pi = \chi - C,$$

where C is the topocentric position angle of the direction of the central meridian of the Moon. Π corresponds to the so called Watts' angle. The profile of the limb in Figure 1 is drawn according to the Watts' charts with the above Π as the argument for entry to the charts without any modification.

We notice that the map and the photograph show a resemblance each other, i.e. some common features are seen both in the map and the photograph. A detailed comparison between them gives the result that the position angle of the Watts' charts is larger than the true value by 0.11°. In other words, the above computed Π plus 0.11° should be used as the argument when Watts' charts are consulted.

Of course we can only say from the present consideration that the above value of correction is valid in the vicinity of the portion of the limb where the phenomenon occurred. However the value is nearly

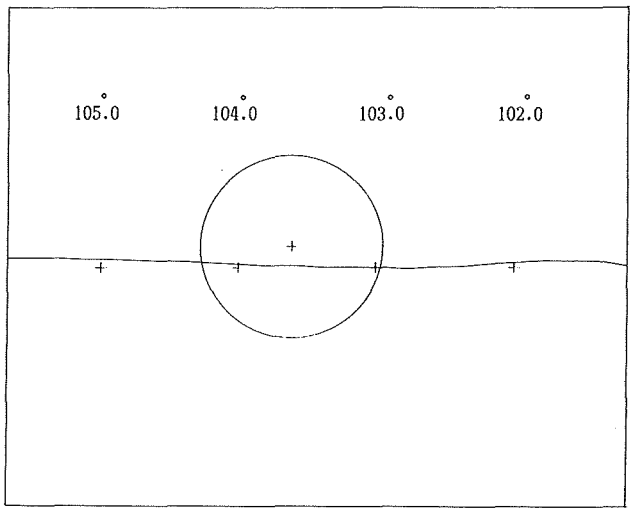

Figure 1 . Computed configuration of Mars and the Moon's limb seen from the Bisei Hydrographic Observatory at $11^h\ 39^m\ 08^s$ UTC, 20 July 1986.

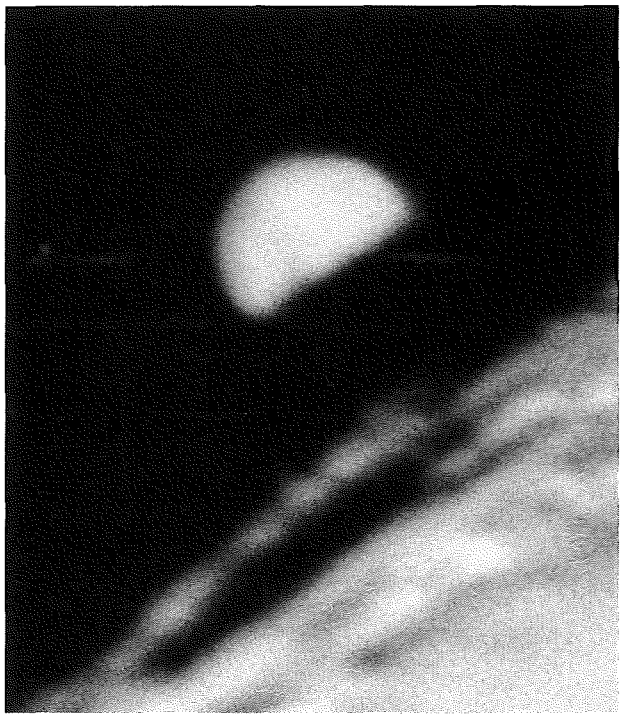

Figure 2 . Photograph of the lunar occultation of Mars taken at the same instant as Figure 1.

accordance with those by the preceding studies. Analyses of many other phenomena of occultations of planets are desirable in order to draw a more reliable conclusion.

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1986年の火星食から求めたワッツ月縁図の位置角の改正量（要旨）

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1986年7月20日に美星水路観測所で撮影された火星食の写真を解析し，従来言われてきたワッツの月縁図の位置角引数の誤差の調査を行った。その結果，これまで報告されていた値に近い−0.11°という改正量が得られた。