Astronomical and Astrophysical Transactions (*AApTr*), 2012, Vol. 27, Issue 3, pp. 509–512,
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Modeling of the lunar visible side figure

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Received 20 November, 2008

The problem of the Moon's macro figure modeling, which referred to its mass center and inertia axes, has not yet received its final decision. The attempt to model the Moon's visible side on space and ground observations was carried out in this study.

Keywords: Selenodesy; Moon; Modelling of a figure

1 Introduction

The methods to obtain observations presupposed the lunar objects binding to the stars, to the celestial coordinate system. The Moon's pictures with stars and "Clementine" mission data were used as the observations. Five models were built with the software and analytic complex of Ulyanovsk Technical State University.

It was of interest to compare the hypsometric level, which was set by the independent selenocentric coordinate system of "Kazan" catalogue (hereinafter referred to KZ-1) (Khabibullin, Rizvanov, 1984) and Kazan-1162 catalogue (hereinafter referred to KZ-1), which were obtained by the Moon pictures with stars, with a relief formed by the heights set, obtained in the "Clementine" mission (hereinafter referred to CL) (Smiz, 1977). However, the conventional mean hypsometric level will be set by "Golosievo" catalogue (hereinafter referred to KV) (Gavrilov, Kislynk, Duma, 1977). The idea and the mathematical software for the comparison of three sources about relief data are as follows. Knowing that geometrical sections of the Moon's visible half-sphere can be built by the h-height function expansion in the series by spherical functions in the form of

$$h(\varphi, \lambda) = \sum_{n=0}^{N} \sum_{m=0}^{n} (\bar{C}_{nm} \cos m\lambda + \bar{S}_{nm} \sin m\lambda) \bar{P}_{nm}(\cos \varphi) + \varepsilon \qquad (1)$$

(φ, λ – the known coordinates of lunar objects; $\bar{C}_{nm}, \bar{S}_{nm}$ – the normalized coefficients of the spherical harmonics; $\bar{P}_{nm}$ – the normalized associated Legendre functions), we

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will get three versions of the section set. The analysis allows us to make certain judgments about the degree of hypsometric information closeness, set by KZ-1 and KV catalogues, and KZ-2 to the relief of CL mission.

It was detected (Valeev, Rizvanov, Nefedyev, 2004) that the Moon's figure is a hemisphere with an average radius 1736.34 km 1.20 km and with the salient in the center part, the height is about 0.9 km. The relief of the surface is fallen gradually to the north from 10° parallel; the radius-vectors are 0.9 km less than the average radius obtained by us, in the 30°–70° latitudes zone.

We can make the following conclusions from the analysis of KV and KZ-1 catalogues (Valeev, Rizvanov, Nefedyev, 2003) using the investigation of sections for longitudes $\lambda = -40°, -20°, 0°, 20°, 40°$.

- The lowering of the relief in the northern hemisphere according to KZ-1 catalogue is 2–3 km deeper than CL mission. But, the forms of hypsometric curves are generally similar in both sources. The average level of the southern hemisphere is higher than the northern one. The height difference between two systems in this hemisphere is much smaller (about 0.5–1.0 km).

- The lowering of the relief for the northern latitude between 30°–45° according to KV catalogue is the same order as for CL mission. However, the further heights, from KV, increase to 70°–80° latitudes. This leads to a marked difference of hypsometric curves forms.

- The comparison of five hypsometric curves for KZ-1, KV catalogues confirms the earlier conclusions about the lowering of the average relief's level according to KZ-1 data in comparison with KV data in the northern hemisphere of the Moon. The overall decrease is made up from the northern part of the hypsometric KZ-1 section relative to CL and the increase of KV section part.

The section's analysis for the longitudes $\lambda = -40°, -20°, 0°, 20°, 40°$ CL, KZ-1, KV and KZ-2 catalogues gave the following results:

- The comparison of five hypsometric curves sections of the surface models according to CL data and KZ-2 catalogue shows their good agreement.

- The model's relief of the macro figure KZ-2 catalogue, does not produce noticeable decreases or significant increases relative to the space CL experimental data.

- The hypsometric curves comparison of CL data and Kz-1, KV catalogues with KZ-2 confirms the previous conclusions about the reduction of the average relief level according to KZ-1 with the comparison of the KV data in the northern Moon's hemisphere, but the overall decline has the less expressed form than in KZ-1 catalogue and is closest to the magnitude reduction of the observations data of the space CL experiment.

The results of comparison of the lunar surface relief according to ground and space pictures of the Moon and ALSEP system are the following:

- The differences of the absolute altitude in KV, KZ-1 directories have the systematic type for the northern part of the visible Moon's side (Shimerman, 1976). In connection with it, a hypothesis has been put relative to the physical surface figure of the lunar visible side.
- The analysis results of the ALSEP experimental data do not reject the new hypothesis about the relief's lowering of the lunar surface to the north from $+10^\circ$ parallel relative to conventional one
- The data of the Moon picture's reduction with "Zond-8" spacecraft (Rodionov, Nafedjev, Valeev, 1976) with the outside elements at orientation instrument in the coordinate system KZ-1 directory confirm the relief's lowering of the lunar surface the 1.5 km in region $-70^\circ < \lambda < -30^\circ$,$-10^\circ < \lambda < -63^\circ$ relative to the generally accepted level.

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