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Computer simulating of stellar tracks for observations with the lunar polar telescope

N. Petrova [a,b,*], H. Hanada [c]

[a] Kazan Federal University, 18 Kremljevskaja Street, Kazan 420008, Russia
[b] Kazan State Power Engineering University, 51 Krasnoselskaja Street, Kazan 420066, Russia
[c] National Astronomical Observatory, 2-12 Hoshigaoka, Mizusawa, Iwate 023-0861, Japan

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ABSTRACT

A brief description of targets and problems of the future Japanese project ILOM (In situ Lunar Orientation Measurement), which is planned to be realized as one of kinds of observations of lunar rotation at the second stage of SELENE-2 mission, is given in the article. One of the important elements of the project is placing of a small optical telescope on the lunar surface with the purpose to detect the lunar physical libration with high accuracy of 0.001 arc sec. Computer simulation of the future observations is being done with the purpose of their optimisation: effective placement of measuring system on the lunar surface and formation of scheduling of observations for monitoring the physical libration of the Moon. The results of the first stage of the simulation are presented in the paper. At this stage the software for the selection of stars and reduction of their coordinates onto the period of observations is developed, the tracks for the selected stars are constructed and analysed, their sensitivity to the internal characteristics of the lunar body, in the first place, to the selenopotential coefficients, is tested.

Analyses of simulated stellar tracks observable from the lunar surface (in a polar zone) revealed a difference from daily parallels of stars in comparison with ground based observations. During one "lunar day" equal to 27.3 terrestrial days, a star moves along a spiral. In dependence on the longitude of the star, these spirals can be untwisted or twisted. In the latter case a star can describe a loop in the sky of the Moon during the observation period. The reason of such unusual astrometry phenomenon is the combination of the slow rotation of the Moon as compared with the Earth and the fast precession motion of the lunar pole (in comparison with precession motion of a terrestrial pole). Due to the physical libration the shifts of all tracks will be observed towards direction opposite the Earth. The tracks are sensitive to gravity model of the Moon and are different even for the most accurate modern gravity field models—LP150Q (Konopliv, 2000) and SGM100h (Matsumoto et al., 2010).

1. Introduction

The measurement of the rotation of the Moon is one of techniques to get information of the internal structure of the celestial body. The Lunar Laser Ranging (LLR) has given unprecedented data on the lunar rotation, and gives some proposals of the core's state (Dickey et al., 1994; Williams et al., 2001). The lunar project ILOM is an experiment to measure the lunar physical librations in situ on the Moon with a small telescope, which tracks stars (Hanada et al., 2005; Noda et al., 2008). In this case it is not necessary to take into account the atmospheric, spin-orbital effects of the Earth and, as a result, the treatment of the observations is simplified. Project developers propose that all this might give reason to achieve accuracy of lunar rotation up to 0.001 s of arc (Hanada et al., 2005, 2009, 2010).

In the current research we calculate tracks of stars, which will appear in the field of view of the ILOM telescope during the proposed period of observation. The final purpose of the research is to simulate the process of observation and to obtain the "observed" values, which may be used for the estimation of the physical libration parameters. But at the first stage of the theoretical support of the future project, we consider the features of the trajectories of stars when observed with the lunar polar telescope. When the telescope will be posed exactly at the lunar dynamical pole (its axis coincides with the principal inertia axis C of the Moon) and the axes of the CCD-array situated in the lens of the telescope will be ideally directed along the other two principal axes of inertia, the motion of stars will be displayed relatively to the axes of inertia, which are rigidly connected with the lunar body.

* Corresponding author at: Kazan Federal University, 18 Kremljevskaja Street, Kazan 420008, Russia. Tel.: +7 843 510 0572.
E-mail address: nk_petrova@mail.ru (N. Petrova).

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