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Some qualitative manifestations of the physical libration of the Moon by observing stars from the lunar surface

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Abstract

Targets and problems of the future Japanese project ILOM (In situ Lunar Orientation Measurement), which is planned to be realized as one kind of observations of lunar rotation at the second stage of SELENE-2 mission, are briefly described in the article. Inverse problem of lunar physical libration is formulated and solved. Accuracy of libration angles depending on accuracy of measuring selenographic coordinates is estimated. It is shown that selenographic coordinates of polar stars are insensitive to longitudinal librations $\tau(t)$. Comparing coordinates calculated for two models of a rigid and deformable Moon is carried out and components sensitive to Love number k_2 and to anelastic time delay are revealed.

Keywords: Lunar physical libration; Lunar telescope; Selenographic coordinates

1. Introduction

A wide range of methods applied for studying the Moon allowed obtaining a great amount of information, for example, about its internal structure. Methods under development and data obtained during the exploration of the Moon can be applied to other, more distant, objects in the Solar System. That is why a series of lunar space experiments is planned for the next decade in many countries, including Russia, particularly with the use of measuring apparatus, placed on the Moon's surface.

One of the most important observation targets is the rotation of celestial bodies. This phenomenon is a kind of a key to the internal structure of a celestial body, because many variations in its observable rotation reflect the peculiarities of its invisible complicated inner stratigraphy. In this connection, the lunar experiments aimed at the study of the lunar physical libration (LPhL) are of great interest.

Lunar Laser Ranging (LLR) has been continued for longer than 40 years with the intention to study the Moon as well as the Earth, orbit evolution and the general relativity. Many important phenomena related to the lunar interior were found from the LLR so far (Dickey et al., 1994; Newhall and Williams, 1997; Williams et al., 2001). Williams et al. (2001) detected phase differences due to dissipation inside of the Moon in several components of the physical librations from LLR data and suggested dissipation within the core-mantle boundary or a liquid core in the Moon. Improvement of the accuracy and new observations with better accuracy are necessary for better elucidation of the deep interior of the Moon.

Optical astrometric observations as well as the advanced LLR with a new reflector and a new network, and the advanced VLBI (Very Long Baseline Interferometer) are new trend for observations of the lunar rotation in a future lunar mission after the success of SELENE (Kaguya) and Chang'E-1/2 (Hanada et al., 2012).

One of the necessary stages of preparation for the upcoming experiments is the theoretical simulation of the

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