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The study of the spin–orbit and inner dynamics of the Moon: Lunar mission applications

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Abstract

In view of the forthcoming Lunar mission SELENE (Japan) with geodetic experiments on board and with an optical telescope on the lunar north pole, a contribution of the theory of lunar rotation in order to study of inner dynamics is considered. Our present knowledge of the interior structure is reviewed, and it is shown how the data from SELENE can be used to improve this knowledge. The emphasis is put on the evidences of lunar core existence and on the necessity to take this fact into account in the lunar libration theory. It is considered, that in accordance with the general properties of resonant motion the synchronous satellites execute some free oscillations in the neighborhood of the stationary periodic solutions (in the neighborhood of Cassini's motion). The periods of these librations are evaluated. The model of the two-layer Moon gives several normal rotational modes; one of them – the Free Core Nutation (FCN) – can play an important role in the determination of the core's parameters.

Keywords: Lunar rotation; Lunar core; Free libration

1. Introduction

In present days, the Moon has become the target of several space missions as well as the focus of attention for researchers in Astronomy and Planetology. The topics to be addressed include their rotational motions as well as their internal activity. Today the most interesting data on dynamics and internal structure of the Moon are already accumulated as a result of the different observations and space experiments. These are Clementine mission (1994), Lunar Prospector (1998–1999), Lunar Laser Ranging (LLR) data analyses, performed during a 35 year period, the European lunar mission SMART-1, which was launched in September 2003.

The Japanese space experiments, Lunar_A and SELENE-mission, planned for the years 2006–2008, will contribute significantly to the information about the Moon. In particular, the SELENE-mission (Kawano et al., 2003) is directed on the investigation of the lunar gravity field and topography on the far side, using the tracking data of satellites with differential VLBI.

In situ Lunar Orientation Measurement (ILOM) is directed to study lunar rotational dynamics by the direct observations of the lunar physical librations from the lunar surface in the SELENE-B project. The ILOM telescope will observe the motion of the stars around the pole of the sky in order to measure the physical librations of the moon, which solves the interior structure of the Moon.

The main component is a compact PZT telescope deployed near the lunar pole. The PZT is suitable for a positioning telescope ($d = 20$ cm, focal length = 1–2 m)

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