EPSC Abstracts,
Vol. 4, EPSC2009-508, 2009
European Planetary Science Congress,

Lunar Rotation and Gravity Measurements by SELENE-2

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Abstract

Long-term observation of lunar rotation variability can constrain the state of lunar mantle and core through physical librations. Three instruments measuring lunar rotation on board SELENE-2 (and further missions) are proposed: ILOM (In-situ Lunar Orientation Measurement), Inverse VLBI, and LLR (Lunar Laser Ranging).

SELENE-2

Japan will launch a lunar landing mission (SELENE-2) on the nearside of the moon, following the successful KAGUYA (SELENE). We propose instruments measuring lunar rotation on board SELENE-2 (and further missions): ILOM (In-situ Lunar Orientation Measurement), Inverse VLBI, and LLR (Lunar Laser Ranging).

Long-term observation of lunar rotation variability will determine various components of physical librations and possibly of free librations. Those components can provide information of the state of lunar mantle and core, i.e., whether the lunar core is molten or not. Together with seismic and gravity data, these data can be used to investigate the interior of the moon, and thus the origin of the moon.

LLR

So far, observations of physical librations and free librations have been done by Lunar Laser Ranging (LLR) for more than 25 years. There were produced data on the state of the core. SELENE-2 will bring CCRs (Corner Cube Reflectors) for LLR measurements. We are also studying active LLR where laser pulses will be shot from the lunar surface by the triggering laser signals from the Earth. The active LLR can enhance the accuracy of the lunar rotation measurements.

ILOM

The ILOM (In-situ Lunar Orientation Measurement) is an optical telescope which can track trajectories of stars and then provide information of variability of lunar rotation. Since the ILOM observation is done on the lunar surface, orbital motion is separated from the rotational motion. We expect direct observations of the lunar physical and free librations with an accuracy of 1 millisecond of arc. As for ILOM, we applied a photographic zenith tube (PZT) telescope, which is similar to ones used for the international latitude observations of the Earth. The ILOM optical telescope is small in size (20 cm in diameter) but it can be considered as a precursor for the future larger telescopes. We have developed BBM model for stability and optical tests (Fig. 1).

Figure 1: BBM of ILOM (Iwate Univ.)

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I-VLBI

The I-VLBI (Inverse VLBI) can measure the distance difference between two landers on the moon very precisely. The time signals of the radio sources in both landers will be synchronized through the orbiter. Relative VLBI observations of landers from several ground stations can provide very accurate information of rotation variability of the moon.

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