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Development of a Telescope for In-situ Lunar Orientation Measurements (ILOM) in the next Lunar Exploration - Evaluation

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We are proposing a selenodetic observations by using an optical telescope on the Moon to study lunar rotational dynamics in post-SELENE mission. Main targets are direct observations of the lunar physical libration and the free librations of the Moon. A small telescope like PZT set near the lunar surface determines the orientation of the axis of rotation of the Moon by positioning of several tens of stars in the field of view at every moment for longer than one year [1]. An accuracy better than 1 mas is necessary in order to put a strong constraint upon the structure and property of the lunar deep interior, such as the existence of liquid core, since libration parameters related to property of the lunar core have amplitude of at most a few mas [2].

We have already developed a BBM (Bread Board Model) of the telescope and made some experiments in order to know the performance of the optical system and the driving mechanism under similar condition to lunar environment showing high vacuum, large temperature change and dusty condition.

The important problem which can affect the accuracy is effects of temperature change. We evaluated the effects of temperature change upon shifts of star images by simulations using a ray tracing method. The patterns of the shifts due to uniform temperature change are similar to divergent flows from the origin, and we can correct for the pattern of the shifts by using linear functions with the accuracy better than 1 mas. The other kind of effect such as horizontal or vertical temperature gradient causes shifts of star images in one direction as well as radial shifts, and we need more complicated model for correction.

After the performance test of the motor under the vacuum of 3 Pa for 8 to 29 hours, we found that the temperature near the motor increased. We need to establish the condition concerning the operation of the motor in order not to cause any damage in the driving mechanism.

[1] Hanada, H., Heki, H., Araki, H. et al., Application of PZT telescope to In-situ Lunar Orientation Measurement (ILOM), International Association of Geodesy Symposia, 2004, 128, 163-168.
[2] Williams, J. G., Boggs, D. H., Yoder, C. F. et al., Lunar rotational dissipation in solid body and molten core. 2001, J. Geophys. Res., 106, 27933-27968.

Keywords: lunar rotation, telescope, PZT, physical libration, lunar exploration