

## Summary of the development of a small telescope for lunar rotation and the experiments on the ground.

HANADA, Hideo<sup>1\*</sup> ; TSURUTA, Seiitsu<sup>1</sup> ; ASARI, Kazuyoshi<sup>1</sup> ; ARAKI, Hiroshi<sup>1</sup> ; NODA, Hiroto<sup>1</sup> ;  
KASHIMA, Shingo<sup>1</sup> ; FUNAZAKI, Ken'ichi<sup>2</sup> ; SATOH, Atsushi<sup>2</sup> ; TANIGUCHI, Hideo<sup>2</sup> ; KATO, Hiromasa<sup>2</sup> ;  
KIKUCHI, Mamoru<sup>2</sup> ; YOKOKAWA, Ringo<sup>2</sup> ; SHINKE, Syota<sup>2</sup>

<sup>1</sup>RISE Project, National Astronomical Observatory, <sup>2</sup>Faculty of Engineering, Iwate University

We have been developing a small telescope like Photographic Zenith Tube (PZT) for observations of lunar rotation since the 1990s. We know the lunar rotation by positioning of stars from the lunar surface, and the accuracy of 1 milli-arc-second (1mas) can detect components of physical librations related to dissipation in the Moon. Observation of lunar rotation is one of the essential and basic observations for investigating the interior of the Moon.

We have already developed a bread board model (BBM) of a PZT type telescope for basic experiments. Technical development for improvement of the accuracy, environmental test of key elements were made by using the BBM. A new tripod makes it possible to set the telescope on the slope of less than 30 degrees, and it keeps the tube vertical within the error of 20 arc-seconds. PZT has a potential to observe deflection of the vertical (DOV) with an accuracy better than 0.1 arc-seconds on the ground. It will be possible to reduce the effect of atmospheric turbulence to be smaller than 0.1 arc-seconds by statistical procedure of observed data. It is also possible to reduce the effect of the ground vibrations to be less than 0.1 arc-seconds judging from the laboratory experiments.

We performed observations on the ground in September of 2014, in order to check the total system of the telescope and the software. It is also important to evaluate the effect of the ground vibrations and temperature change upon the stellar position on CCD. The goal of the observations on the ground is to attain the accuracy of better than 0.1 arc-seconds. The results of the preliminary observations showed that the scatter of stellar positions was about 0.4 arc-seconds, which is a little larger than expected. It is partly due to insufficient signal to noise ratio of star images. Verification of 1 mas on the Moon will be possible in a laboratory equipped with a special space chamber providing the environment on the Moon in the future.

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