

Development of a Small Digital Telescope for Observations of Lunar Rotation

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We have developed a BBM (Bread Board Model) of a digital telescope for ILOM (In-situ Lunar Orientation Measurement) and made some experiments in order to know the performance of the optical system and the driving mechanism under the lunar environment. It is a special small digital telescope like PZT (Photographic Zenith Tube) for study of lunar rotational dynamics with the target accuracy of 1 milli-second of arc (1 mas).

Effect of large temperature change is one of the most serious problem for such a precise observation. We propose two methods for reducing the effects of such a large temperature variation. One is to use a diffractive lens, and another is to correct the effects by making use of the characteristic patterns in the shifts of star images. Ray tracing simulations show that the tolerance for the temperature change becomes wider by about one order of magnitude by introducing the diffractive lens, and it suggests that the temperature change of up to 5 degrees is allowed for the observation change of 1 mas, which is more than one order of magnitude larger than that for conventional lenses. Regarding the another method, we succeeded in approximating the effects of uniform temperature change with better than 0.03nm on the CCD array or 10 micro-second of arc by using a linear function of temperature.

The attitude control system, on the other hand, can make the tube vertical within an error of 0.006 degrees (or about 20 arc-seconds), which is within the tolerance for the measurement of 1 milli-arc-second accuracy by using PZT. Performance of the mechanical system on the Moon is evaluated by vacuum test, and there is no serious problem hitherto.

We also investigated possible optical effects upon the central position of star images such as the ghost, off focus, stray rays, scattered rays, diffractive rays of unnecessary degrees and vibration of mercury surface by using ray tracing simulations and experiments. The effects are proved to be far below the 1 mas level except the effect of vibration of the mercury surface which is under investigation.

Keywords: Lunar rotation, telescope, PZT, physical libration, internal structure