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測月学および測地学のための小型望遠鏡の開発におけるいくつかの技術的課題
Some technological problems in development of a small Telescope for selenodesy and geodesy

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Observations of the lunar rotation are one of the essential and basic selenodetic observations for investigation of the interior of the Moon as well as those of gravity fields, and high accuracy of the observations have a potential to detect signals related to the structure of lunar deep interior including the core. Technological development dedicated to highly accurate observations for the Moon, on the other hand, can return to the application to the Earth again. We are developing a small telescope for observations of Lunar rotation with a target accuracy of 1 milli arc second, and it has a potential to observe deflection of the vertical on the ground with high accuracy. This accuracy is epochal also for the observation of the deflection of the vertical even if it may be deteriorated to some extent by atmospheric fluctuations etc.

Major problems in the observations on the Moon are large temperature change and the difficulty of adjustment. We developed an objective using a diffractive lens in order to loosen the condition of the temperature change, and we adopted PZT (Photographic Zenith Tube) having a horizontal reference plane of a mercury surface in order to realize an adjustment-free system. Observations on the ground, on the other hand, are mostly affected by ground vibrations and atmospheric fluctuations. The effect of temperature change is not very large and it is relatively easy to control the temperature around the tube.

As the results of laboratory experiments, it is possible that the vibration of the mercury surface caused by the ground vibrations lead to fluctuations of star positions on CCD as large as 1 second of arc. The amplitude of the fluctuations depend on the amplitude of the ground vibrations and the depth of mercury pool. We can reduce the effect of the vibrations by making the mercury pool shallow down to the minimum depth. In the case of the mercury pool of 64mm diameter, the depth of 0.5mm is the minimum depth judging from our experience. Shallower pool will shorten the life time and will be affected more easily by the tilt.

It is important to keep the proper period of the mercury pool away from the period of ground vibrations in order to avoid the resonance. It is also effective to lengthen the integration time, and it can improve the reliability of the mean value of the center of a star image by statistical procedure. Adaptive optics is widely used for compensating the effects of atmospheric fluctuations and for obtaining sharper images approaching the diffraction limit. The adaptive optics, however, is not always effective for the astrometric telescope like PZT because it is possible to shift the center of star image by deformable and tip-tilt mirrors.

We investigate the cause of fluctuations which can affect the observations on the ground, and we explore the possibility for a new effective observations with the telescope like PZT.

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