Improvement of the seismometer of LUNAR-A penetrator and its performance

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We improved a seismometer for LUNAR-A mission. In the LUNAR-A mission, two penetrators will be settled on the different sites of the moon surface. Observation of the moonquakes will be taken place by the two-axes short period (~1Hz) seismometers of the penetrator. The other measurement of thermal characteristics on the lunar regolith will also be taken place. The seismometer is a conventional moving coil type and its output signal is proportional to the ground velocity. The seismometer is very light in weight, ca. 350g, and small in size, ca. 5cm long and 5cm in diameter for the usage of planetary mission, and is very strong, more than 7000G shock tight, for hard landing of the penetrator. The present seismometer possesses about 1Hz natural frequency, which is achieved by the assist of magnetic interaction among magnetic circuit and two small ferric parts placed on the pendulum. The conventional spring and pendulum system in the size of the present seismometer is 2.0~3.0 Hz natural frequency.

The neutral position of the pendulum should be the same when the pendulum returned from one end and returned from the other end. However, the seismometer for the LUNAR-A mission has the different position of the pendulum directly by using a newly developed measuring system with a laser ranger and a reflecting marker placed directly on the pendulum. Observed displacement data are analyzed and the candidate causes are selected. One of the most probable cause is a magnetic hysteresis of the ferric parts. The material of the ferric parts is a three nine iron (pure iron). The force applied to the parts and therefore the pendulum due to magnetic interaction is measured directly by using a newly developed force measurement system, which is made by a precise load cell and an actual magnetic circuit of the seismometer. By using the system, we detected the magnetic hysteresis of the pure iron, which arises the displacement of natural position of the pendulum up to several tens micron meters. Then, as the ferric parts, we employed the permalloy-78(Ni78%-Fe alloy) and the magnetic circuit did not show any detectable hysteresis, and observed natural position of the pendulum did not show any detectable displacement.

The seismic observation for several months is made at the Inuyama Seismic Observatory of Nagoya University. The very small ground motions are observed by the LUNAR-A seismometer, L-4 (Mark Product, ~1Hz), and STS-2. Compared seismograms and power spectrums show that the presently improved seismometer possesses more sensitive characteristics in the frequency range from 0.2 to 30 Hz than both well-known seismometers of L-4 and STS-2.