Lunar Heat Flow Measurement by the LUNAR-A penetrator; estimation by unsteady state analysis

Shinsuke Yoshida[1], Yuka Miyazaki[2], Satoshi Tanaka[1], ki'ichi hourai[1], Hitoshi Mizutani[1], Akio Fujimura[1], Ken'ichi Hirai[3]

[1] ISAS, [2] Earth and Planetary Sci. Tokyo Univ, [3] IA

In situ lunar heat-flow measurements will be carried out by using two Lunar-A penetrators, which will be deployed on the near-side and the far-side of the lunar surface. Each penetrator has seven absolute and eleven relative temperature sensors, which measure the temperature gradient of the penetrator's body. However, the temperature field in the lunar regolith around the penetrator will be significantly disturbed by the penetrator itself, and thus a detailed analysis of the temperature field within and around the penetrator is required for quantitative determination of the original temperature gradient, and hence the heat-flow value.

In order to construct the thermal model of the penetrator, we first made measurements of thermal conductivities and heat capacities for several major components of the Lunar-A penetrators. The experimental error of the measured values are estimated to be better than 10 % in the temperature range from 0 to - 20 degC which is near the temperature condition expected in the lunar regolith around the penetrator. Combing the experimental values of the thermal properties of the major components and some theoretical/empirical estimates of the thermal properties of other components, we constructed the initial thermal model of the Lunar-A penetrator. The initial thermal model is then revised to fit the experimental data of a thermal test on a whole penetrator, leading to the final thermal model.

With the final thermal model of the penetrator, we numerically simulate the temperature field around the penetrator in the lunar regolith. The result of the simulation indicates that the temperature difference between the top and the bottom position of the penetrator will be around 0.1 K. Since its temperature difference is directly connected with the temperature gradient of the lunar regolith, we also calculated the effect of the uncertainty of the thermal model on the temperature difference. The result of the numerical analysis indicates that uncertainty of the current thermal model may induce about 6 % error to the estimate of the temperature gradient of the lunar regolith if the measurement is made in steady state.

However it is not probable that the heat flow measurement is made in steady state, because the seismic experiments and data transmission between the penetrator and the mother spacecraft will generates heat within the penetrator at a fatal level for the heat flow measurement, from several weeks after the penetration. The result of the numerical analysis indicates that uncertainty of the current thermal model may induce about 10 % error to the estimate of the temperature gradient of the lunar regolith if the temperatire of the penetor is 0 degC and the measurement is made for two weeks without internal heating.

The effect of penetrator's power-on heating (33mW) is also studied and the result will be reported.