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Development of a Triple-Reflection Compact Time-Of-Flight Mass Spectrometer for Lunar Polar Exploration

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In order to investigate the presence (and amount) of the water (ice) molecules in the regolith 1 to 1.5 m below the lunar surface, a compact neutral particle mass spectrometer is under development. This neutral particle mass spectrometer is designed to install on a Moon rover, and it will perform mass analysis of neutral gas generated in the heating chamber. This mass spectrometer not only aims to measure the amount of water molecules included in the lunar regolith but also identify the atoms, molecules and their isotopes up to mass number 200 with mass resolution as high as 100.

The mass spectrometer under development is a reflectron that is a Time-Of-Flight mass spectrometer. A standard reflectron consists of an ion source, ion acceleration part, free flight part, ion reflection part and an ion detector. Ionized neutral particles are accelerated in the two-stage ion acceleration part by a pulsed high voltage whose pulse timing is used as a start signal. The accelerated ions enter into the free flight part and reflected in the single-stage ion reflection part. Reflected ions again fly through the free flight part and detected by a detector. Ion mass is determined by the time difference between the start signal and the particle detection.

In order to increase the mass resolution as much as possible within the allocated volume, we have decided to modify the standard reflectron by adding a second reflector that enables triple reflections and doubles the flight length. This newly designed triple-reflection TOF mass spectrometer can be operated also as a standard reflectron by changing the electric field configuration. Since the triple-reflection reduces the detection efficiency while increasing the mass resolution, the single reflection mode is used as a complementary mode where the detection efficiency is higher while the mass resolution is lower.