Secondary ion observation for remote sensing of the lunar surface materials

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The Moon is exposed to the solar wind when it is located outside the Earth’ s magnetosphere. The solar wind directly impacts the dayside lunar surface since the Moon has neither global magnetic field nor thick atmosphere. The secondary ions are emitted from the lunar surface by the solar photon or the solar wind ion bombardment. Although the initial energies of such secondary ions are several eV, they are accelerated up to several hundred eV by the solar wind motional electric field and are detected by ion detectors on spacecraft. The secondary ion composition is expected to be used for remote sensing of the lunar surface since it depends on the lunar solid surface composition. However, neither the quantitative observation of the secondary ions nor the detection of the originating points has been made.
MAP-PACE-IMA on Kaguya has performed energy and mass measurement of ions around the Moon, and quantitative observation of the Moon originating secondary ions has been made for the first time. We have investigated a variety of ion species such as H+, He++, 3He+, 4He+, C+, N+, O+, Na+, Mg+, Al+, Si+, P+, S+, Ar+, K+, Ti+, Cr+, Mn+, Fe+ and Zn+. We have also detected the originating points using the solar wind convection electric field information.
There are a few major generation mechanisms of the Moon originating secondary ions; photon-stimulated desorption (PSD) by the solar photons, ionization of neutral particles by the solar photons, and sputtering by the solar wind ions. The secondary ions generated by the solar photons consist of Alkali ions such as Na+ and K+. In contrast, a variety of ion species can be generated by the ion sputtering process. At locally magnetized regions called lunar magnetic anomalies (LMAs), the solar wind ion is reflected by the strong crustal magnetic field. We have compared the generated ion flux at LMA region with that at non-LMA region. As a result, we have established an analysis method to compare the amount of ions generated by PSD with that by the solar wind sputtering. In addition, we have investigated a relation between the Moon originating secondary ions and the lunar surface location. In conclusion, although the secondary ion observations do not directly reproduce the lunar surface composition, it is possible to extract the information about lunar surface composition if we consider the existence of the lunar magnetic anomalies and the generation process of the secondary ions. This result is expected to be applied not only to the Moon but also to various astronomical bodies.

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