Solar Wind Proton Scattering at the Lunar Surface

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MAP-PACE on Kaguya (SELENE) completed observation of the low energy charged particles around the Moon from 100km-altitude polar orbit. MAP-PACE consists of 4 sensors: two electron sensors (ESA-S1, ESA-S2) and two ion sensors (IMA, IEA). Since each sensor has a hemispherical field of view, two electron sensors and two ion sensors that are installed on the spacecraft panels opposite to each other can make full 3-dimensional measurements of low energy electrons and ions. The interaction between the solar wind and the lunar surface has not been understood well until Kaguya observed the plasma environment around of the Moon. Especially, the behavior of the solar wind ions after impacting the lunar surface has never been observationally clear. IMA on Kaguya found the scattering of the solar wind protons where the solar wind protons lose energy by the interaction with the lunar surface.

We have investigated the angular dependence of the scattering and energy spectra of the scattered ions by using IMA data obtained dividing the hemispherical field of view into 16*64 sectors.

The maximum energy of the scattered ions was slightly lower than the energy of the solar wind ions, and it had no clear dependence on the spacecraft position. On the other hand, the minimum energy of the scattered ions had clear dependence on the position (latitude) of the spacecraft. The minimum energy was lowest at latitude 0 deg. and increased when the spacecraft was in the polar region. The output angle of the scattered ions was small in the polar region where the incident angle of the solar wind ions to the lunar surface was small. When the incident angle became larger, the scattered ions had two components (scattered ions with a small output angle and largely scattered ions). The solar wind ions were almost vertically scattered in the sub-solar region, and the angular distribution of the scattered ions were much wider than that in the polar region.

Variations of the magnitude of the energy loss and the output angle with respect to the incident angle of the solar wind strongly reflects the mechanism of the proton scattering at the lunar surface.