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Remote sensing of the lunar surface using low energy ions from the Moon

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Interaction between the solar wind and a solar system object varies largely according to the object's properties, such as the existence of a global intrinsic magnetic field and/or thick atmosphere. It is well known that the Moon has neither global intrinsic magnetic field nor thick atmosphere. Different from the Earth's case where the intrinsic global magnetic field prevents the solar wind from penetrating into the magnetosphere, solar wind directly impacts the lunar surface. In the Earth's magnetosphere, where the Moon stays for $3 \sim 4$ days every month, hot plasma-sheet plasmas in the Earth's magnetosphere (instead of the solar wind) can impact the lunar surface. On the other hand, the ions generated or reflected / scattered at the lunar surface are accelerated by the solar wind / magnetotail convection electric field and are detected by ion detectors on the spacecraft orbiting around the Moon. Since these ions have information about the lunar surface structure / composition, they can be used for remote sensing of the lunar surface.

Solar wind protons reflected / backscattered at the lunar surface is one of the ion populations observed on the dayside of the Moon. The solar wind protons that impact the lunar surface are mostly scattered backward inside a scattering cone with $\pm$ 40deg. whose center axis is opposite to the incidence direction of the solar wind. It is also found that the energy decrease of the backscattered solar wind is most significant along the axis of the scattering cone. In order to investigate the global distribution of the backscattered solar wind protons, we have made a backscattered proton intensity map. Since the magnetic anomalies magnetically reflect the incident solar wind ions, we have made the backscattered proton intensity map by masking the major magnetic anomalies on the lunar surface. The backscattered proton intensity map shows that the relatively intense backscattering was observed on the lunar maria regions. It indicates that the backscattered protons can be used for remotely sensing the lunar surface structure.

The ions originating from the Moon surface are observed both in the solar wind and in the Earth's magnetosphere. The mass spectra of these ions show heavy-ion peaks including C+, O+, Na+, K+, and Ar+ that indicate that these ions are the Moon origin. In the Earth's magnetosphere, these ions are clearly observed on the dayside of the Moon in the lobe especially when the solar zenith angle is below 40deg. These ions often show characteristic variation of the flux that presumably correlates with the lunar surface structure or composition. In order to understand this variation in more detail, we have made ion flux maps by separating ion species. We have newly found that there exist ion flux intensity variations of some the ion species that show good correspondence with the lunar surface locations. It indicates that ions originating from the Moon surface can be used for remotely sensing the lunar surface composition.