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Interaction between the Moon and the Earth's magnetosphere observed by MAP-PACE on Kaguya

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The Moon stays in the Earth's magnetosphere for $3 \sim 4$ days every month. The hot plasma-sheet plasmas in the Earth's magnetosphere can directly impact the lunar surface since the Moon has neither global intrinsic magnetic field nor thick atmosphere. As a result, the lunar surface is negatively charged even on the dayside of the Moon. MAgnetic field and Plasma experiment – Plasma energy Angle and Composition Experiment (MAP-PACE) on Kaguya (SELENE) measured lunar plasmas in a polar orbit with an altitude of 100km, 50km, and in an elliptical orbit with perilune altitude as low as 10km. Although the plasma density in the Earth's magnetosphere around the Moon orbit (at about 60Re) was quite tenuous, MAP-PACE sensors succeeded in measuring characteristic ion / electron distributions in the Earth's magnetosphere including lobe cold ions, fast flowing ions associated with plasmoids, and cold ion acceleration in the plasma sheet / lobe boundaries. According to MAP-PACE observations, several characteristic phenomena caused by the interaction between Earth's magnetosphere and the lunar surface were so far found: 1) Ions originating from the Moon surface / exosphere [Tanaka et al., GRL 36, L22106, 2009], 2) Gyro-loss effect of electrons in the lobe / plasma sheet [Harada et al., GRL, 37, L19202, 2010], 3) Lunar surface charging to negative potential in the plasma sheet (even on the dayside of the Moon) and 4) Energy dispersive structure of the plasma sheet ions reflected / scattered at the lunar surface.

The ions originating from the Moon surface / exosphere are observed both in the solar wind and in the Earth's magnetosphere. The mass profile of these ions show heavy-ion peaks including C+, O+, Na+, K+, and Ar+ which indicates that these ions are the Moon origin. In the Earth's magnetosphere, these ions are clearly observed when the Moon is in the magnetospheric lobe, on the dayside of the Moon. Since the convection electric field in the lobe region is much weaker than in the solar wind, the ions originating from the Moon surface / exosphere are possibly accelerated by the potential difference between the lunar surface and Kaguya. These ions often show characteristic energy / time variation. If these ions are accelerated by the potential difference between the lunar surface and Kaguya, the energy / time variation reflects the surface potential distribution on the lunar surface.

Energy dispersive structure of the plasma sheet ions reflected / scattered at the lunar surface is another example of the interaction between the lunar surface and the Earth's magnetosphere. When the hot plasma sheet ions impact the lunar surface some of them are reflected / scattered. Sometimes the reflected / scattered ions show energy dispersive structure where higher energy ions are observed earlier. This energy dispersion reflects the non-uniform reflection / scattering of the plasma-sheet ions on the lunar surface.

The plasmas observed around the Moon when the Moon is in the Earth's magnetosphere is gradually unveiling their characteristics. Understanding these phenomena will contribute to our understanding of the interaction between magnetosphere and non-magnetized airless bodies in general.