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Ions originating from the Moon surface / exosphere observed in the Earth's magnetosphere

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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. When Kaguya stayed in the Earth's magnetosphere, one of the MAP-PACE sensors IMA (Ion Mass Analyzer) detected ions from the Moon surface [Tanaka et al., GRL 36, L22106, 2009]. These ions were observed when the Moon was in the magnetospheric lobe, on the dayside of the Moon, especially when the solar zenith angle was below 40 degrees. IMA detected peaks for the heavy ions including C+, O+, Na+, K+, and Ar+ that indicated that these ions were originating from the Moon surface / exosphere. When these ions were discovered, they were considered to be accelerated by the potential difference between the lunar surface and Kaguya. Both the lunar surface and Kaguya were positively charged on the dayside of the Moon since photoelectron and electron currents are the major current sources and the photoelectron current dominates the current balance. Since the Debye length was larger than the spacecraft and much smaller than the Moon, it might be possible for the Moon surface to be positively charged to a higher potential than Kaguya. However, the recent detailed study on the ion flow direction with respect to the magnetic field revealed that the ion flow direction was mostly perpendicular to the magnetic field. It suggests that these ions were mostly accelerated by the convection electric field in the Earth's magnetotail. This hypothesis was proved by investigating an example that lobe cold ions were detected by another MAP-PACE ion sensor IEA while ions originating from the Moon surface / exosphere were detected by IMA. The ions originating from the Moon surface / exosphere also showed characteristic variation of the flux intensity that presumably related with the lunar surface structure or composition. Understanding the lunar plasmas will contribute to our understanding of the interaction between solar wind / magnetosphere and numerous non-magnetized airless bodies.