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The solar wind - Moon interaction discovered by MAP-PACE onboard KAGUYA

Y. Saito (1), S. Yokota (1), T. Tanaka (1), K. Asamura (1), M. N. Nishino (1), T. Yamamoto (1), H. Tsunakawa (2), Kaguya Map Team

(1) Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency, Kanagawa, Japan, (2) Tokyo Institute of Technology, Tokyo, Japan (saito@stp.isas.jaxa.jp / Fax: +81-427598456)

Abstract

Magnetic field And Plasma experiment – Plasma energy Angle and Composition Experiment (MAP-PACE) onboard the KAGUYA (SELENE) spacecraft continuously observed low energy charged particles around the Moon from 100km-altitude polar orbit for more than a year [1]. After completing the nominal mission, KAGUYA lowered its orbit to 50km-altitude and to further lower orbit of ~20km altitude. The newly observed data show characteristic ion distributions around the Moon. Besides the solar wind, low energy ion analyzers have discovered four clearly distinguishable ion distributions in the dayside of the Moon: 1) Solar wind ions reflected/scattered at the lunar surface [2], 2) Solar wind ions reflected by magnetic anomalies on the lunar surface, 3) Ions that are originating from the solar wind ions reflected/scattered at the lunar surface and are picked up and accelerated by the solar wind convection electric field [2], and 4) Ions originating from the lunar surface / lunar atmosphere [3].

One of the most important discoveries of the ion mass spectrometer (MAP-PACE-IMA) is the first in-situ measurements of the alkali ions originating from the Moon surface / atmosphere [3]. The ions generated on the lunar surface by solar wind sputtering, solar photon stimulated desorption, or micro-meteorite vaporization are accelerated by the solar wind convection electric field and detected by IMA. The mass profiles of these ions show ions including He^+, C^+, O^+, Na^+, and K^+/Ar^+. The heavy ions were also observed when the Moon was in the Earth's magnetotail where no solar wind ions impinged on the lunar surface. This discovery strongly restricts the possible generation mechanisms of the ionized alkali atmosphere around the Moon.

When KAGUYA flew over South Pole Aitken region, where strong magnetic anomalies exist, solar wind ions reflected by magnetic anomalies were observed. These reflected ions had nearly the same energy as the incident solar wind ions, and their flux was more than 10% of the incident solar wind ions. At 100km altitude, when the reflected ions were observed, the simultaneously measured electrons were often heated and the incident solar wind ions were sometimes slightly decelerated. At 50km altitude, when the reflected ions were observed, proton scattering at the lunar surface clearly disappeared. At ~20km altitude, the interaction between the solar wind ions and the lunar magnetic anomalies was remarkable with clear deceleration of the incident solar wind ions and heating of the reflected ions as well as significant heating of the electrons. These newly discovered plasma signatures around the Moon are the evidences of the smallest magnetosphere ever observed.

References

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