太陽風ー月相互作用：チャンドラヤーン１号衛星搭載ＳＡＲＡによる最新結果レビュー

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Solar wind-Moon interaction: Review of Chandrayaan-1/SARA results

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In this talk we review the solar wind interaction with Moon based on the latest results obtained from the SARA instrument on board Chandrayaan-1 spacecraft. We also discuss potential future contributions of the space plasma investigation to lunar sciences.

The SARA sensor was developed to investigate the interaction between the solar wind and the lunar surface and the plasma environment around the Moon. SARA consists of two complementary sensors: SWIM (Solar Wind Monitor), a miniature ion mass analyzer measuring inflowing solar wind and fluxes from the lunar surface, and CENA (Chandrayaan-1 Energetic Neutral Analyzer), an energetic neutral atom (ENA) mass spectrometer looking down to the lunar surface to measure sputtered or scattered neutral atoms. Both sensors were successfully commissioned in the end of January 2009 and provide unique dataset for about a half year.

By the CENA sensor, the first ENA imaging was conducted from the lunar orbit. CENA was originally designed for detecting the sputtered surface materials, however, it also detected unexpectedly strong ENA flux from the surface (Wieser et al. 2009a). Since the species of the ENAs were identified as proton and the ENA flux clearly depends on the solar wind flux, the detected ENAs are most likely to originate from the solar wind protons. We interpret that a part of the protons are neutralized and scatted back from the surface when the solar wind proton hit the lunar surface. The flux of the ENAs was ˜20% of that of the solar wind. The amount of the flux is consistent with the backscattered proton reported by Saito et al. (2008). Because the surface of the regolith is very rough and chaotic, such high reflection rate has not been expected, and the interaction mechanism between the regolith in space and the solar wind is yet a big puzzle.

Even though the interaction mechanism is not know, such a high backscattering flux of the ENAs can be used to monitor solar wind proton access to the lunar surface. We also analyzed the CENA data when the spacecraft flew over a magnetic structure of crustal origin (called magnetic anomaly). By inverting the ENA flux from CENA data, we obtained a map of the backscattered ENAs [Wieser et al. 2009b]. The backscattered ENA flux shows a depletion inside the magnetic anomaly with an enhancement around the anomaly. This observation indicates that the magnetic anomaly deflectes the solar wind protons, and that the lunar surface inside the lunar magnetic anomaly is partially shielded from the solar wind.

From the SWIM sensor data, several ion species have been identified in addition to the solar wind: A backscattered protons as reported by Saito et al. [2008], protons in the nightside [Nishino et al. 2009a; 2009b; 2010; Wang et al. 2010], and protons associated with the magnetic anomalies. We made an event study of the solar wind intrusion into the lunar wake along the magnetic field using SWIM data [Futaana et al. 2010]. The results are also discussed in this talk.