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Shielding against solar wind proton flux by magnetic anomalies of the Moon

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Abstract

The Moon has no global magnetic field. However, magnetized regions of crustal origin called magnetic anomalies exist, mainly situated at the far side of the Moon. In this talk, we present evidence that the magnetic anomalies strongly deflect the solar wind proton flux based on Chandrayaan-1/SARA ion observations.

Background

Because of the lack of a strong magnetosphere and dense ionosphere, the solar wind interaction with the Moon is quite different from that of the Earth, Mars or Mercury. The lunar surface absorbs the solar wind protons, forming a plasma vacuum region in its wake. On the other hand, there exist distinct magnetized regions of crustal origin. It is called magnetic anomalies, and they are distributed globally. Very little has been known about the interaction between the magnetic anomalies and the solar wind. Russell and Lichtenstein (1975)[1] statistically showed the existence of limb compressions, which is enhancement of the magnetic field magnitude appearing only in specific selenographic regions above the magnetic anomalies. They concluded that the most probable cause of limb compressions is the deflection of the solar wind by the lunar surface magnetic anomalies in the limb region. Lunar Prospector's in situ observations found magnetic anomalies on the lunar surface that can stand off the solar wind (Lin et al. 1998)[2]. They called the interaction region a mini-magnetosphere, inside which the solar wind cannot reach. Futaana et al. (2003)[3] proposed the hypothesis of solar wind reflection at the mini-magnetosphere (or at the mini-bow shock) associated with magnetic anomalies to interpret a non-solar wind proton flux in the vicinity of the Moon.

Observations and Discussion

The Chandrayaan-1 spacecraft was launched in October 2009. It had a polar orbit at 100 km above the lunar surface. Here we used the proton measurement by the SARA/SWIM sensor on board Chandrayaan-1. The SWIM sensor has a field of view of ~9˚x180˚ with energy resolution of dE/E~7%. In this study, we analyzed the SWIM energy spectra recorded between 19 Apr. 2009 and 4 May 2009, when the Moon was located in the solar wind. The calculated distributions of the non solar wind protons clearly show that the solar wind is significantly deflected by the magnetic anomalies on the Moon surface. The signature of the solar wind deflection by the magnetic anomalies agrees qualitatively well with the energetic neutral atom measurement reported by Wieser et al. (2010)[4]. These results indicate that 1) the magnetic anomaly strongly affects the solar wind in near Moon space, and 2) the solar wind implantation and resulting possible water generation (Pieters et al., 2009[5]) is shielded inside the magnetic anomalies.

References

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