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Mini-magnetospheres above magnetic anomalies on the Moon

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Abstract

When solar wind hits the lunar surface, it is partly backscattered as energetic neutral atoms. The intensity of the backscattered energetic neutral atoms is a measure of the intensity of the solar wind reaching the surface. We report on the imaging of lunar magnetic anomalies in backscattered neutral hydrogen atoms.

1. Introduction

The Sub-keV Atom Reflecting Analyzer (SARA) [1,2] instrument on the Indian Chandrayaan-1 spacecraft has resulted in a comprehensive data set about interaction of solar wind with the lunar surface. A large fraction of up to 20% of solar wind hitting the lunar surface is reflected as energetic neutral atoms back to space [3]. This is contrary to the classical assumption that the lunar surface is a perfect absorber.

2. Energetic neutral atom mapping

Imaging properties of SARA allow mapping of this reflection process at small spatial scales. Above strong magnetic anomalies on the surface, energetic neutral atom images show a pronounced reduction in energetic neutral atom flux resulting from the formation of a partial void of the solar wind, a mini-magnetosphere, above these regions [4]. The extent of such mini-magnetospheres depends strongly on solar wind conditions. Several mini-magnetospheres were identified so far in our data, mostly located on the lunar farside. Although SARA observations were made during on average very quite solar wind conditions between February 2010 and August 2010, we imaged the same mini-magnetospheres under different conditions indicating the stability of the phenomenon but also the limiting conditions where solar wind presses the mini-magnetosphere down to the surface. Magnetic anomalies often correlate with surface albedo anomalies. Shielding of the surface from solar wind is a possible reason for such albedo changes. Mini-magnetospheres provide a way to shield the surface from the solar wind. We note however that this shielding is only partially and strongly particle energy dependent. We discuss our measurements in relation to albedo anomalies.

3. Test case for Mercury

In many regards the Moon is an ideal test case for Mercury. The Mercury Magnetospheric Orbiter (MMO), which is part of the BepiColombo mission will carry a replica of the energetic neutral atom instrument flown on Chandrayaan-1. Given the proximity to the Sun and Mercury's intrinsic magnetic field we expect a very dynamic interaction process of the solar wind and the surface. Lessons learnt at the Moon will be very valuable for the interpretation of energetic neutral atom data obtained at Mercury.

4. Summary and Conclusions

Energetic neutral atom imaging has been proven to be a powerful tool to investigate remotely the solar wind interaction with the Moon, or in future, with other atmosphere less bodies such as Mercury. Our observations at the Moon reveal a new class of objects, mini-magnetospheres, and demonstrate a new observational technique to study airless bodies, imaging in backscattered neutral atoms.

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