MAVEN OBSERVATIONS OF MAGNETIC RECONNECTION ON THE DAYSIDE MARTIAN MAGNETOSPHERE. G. A. DiBraccio[1], J. R. Espley[1], J. E. P. Connerney[1], D. A. Brain[2], J. S. Halekas[3], D. L. Mitchell[4], Y. Harada[4], and T. Hara[4], [1]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771 (gina.a.dibraccio@nasa.gov), [2]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80303, [3]Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242, [4]Space Sciences Laboratory, University of California, Berkeley, CA 94720.

Introduction: Unlike planets with a global intrinsic magnetic field, the solar wind is free to directly interact with the ionosphere and upper atmosphere of Mars [1]. Evidence suggests that this framework has facilitated the loss of the extensive atmosphere and water supply believed to have been present on Mars at one time. The only shielding that the Mars receives from solar wind bombardment is in the form of induced ionospheric fields and localized crustal magnetic fields [2]. If magnetic fields are closed with both ends attached to the planet, these crustal anomalies can behave as mini-magnetospheres [3].

The MAVEN mission offers a unique opportunity to quantify the processes that may be responsible for the atmospheric escape to space. Here, we use MAVEN observations to investigate the complex solar wind-planetary interaction at Mars by examining the effects of magnetic reconnection on the induced Martian magnetosphere, formed by the interplanetary magnetic field (IMF) draped around the planet. This study specifically addresses the occurrence of reconnection at the dayside magnetosphere of Mars.

In the induced Martian magnetosphere, reconnection can occur at any location where a magnetic shear is present. The reconnection of crustal fields will enable the exchange of energy between the solar wind and the Martian ionosphere. When this occurs, solar wind plasma is free to access the atmosphere, as evidenced by auroral observations [4,5,6], and the open magnetic fields provide a gateway for planetary particle escape to space. It is important to distinguish the extent of shielding versus open access to the ionosphere in crustal field regions. A similar interaction is expected to take place between the IMF and induced magnetic fields in the ionosphere, facilitating another direct exchange between the solar wind and Martian ionosphere.

MAVEN Observations: Measurements from the MAVEN Particle and Fields package are used to identify and analyze reconnection at Mars. The Magnetometer (MAG) [7], Solar Wind Ion Analyzer (SWIA) [8], and Solar Wind Electron Analyzer (SWEA) [9] offer magnetic field and ion data, which are essential for understanding these dynamics. MAG operates with a sampling rate of 32 Hz, providing vector magnetic field measurements. SWIA measures solar wind ions, producing coarse and fine 3-d distributions in the magnetosphere and solar wind, respectively, in addition to bulk moments. SWEA provides bulk moments and 3-d distributions of electrons in the 3 eV – 4.6 keV energy range.

Methodology: To understand the role of magnetic reconnection at Mars, we will examine the interaction of the IMF in the magnetosheath with both the induced ionospheric magnetic fields and crustal fields. Because the crustal fields rotate with the planet, we only consider those that are situated on the dayside, and therefore have the opportunity to directly interact with the solar wind, for a given orbit. If magnetic reconnection occurs between the IMF and the Martian crustal fields [10], the result will be an open magnetic field with one end attached to the planet and the other in the solar wind. On the other hand, reconnection between the IMF and induced fields works to remove magnetic flux from the system, as these fields are not attached to the planet. However, when reconnection occurs in either scenario, a non-zero magnetic field component normal to the obstacle, B_N, will result.

Minimum variance analysis [11] is used to transform the MAG data into boundary-normal coordinates, from which B_N can be measured. Events identified to have a non-zero B_N, as MAVEN crosses the respective boundary, are selected for further examination. SWIA data are then used to identify plasma heating and energization in the form of Alfvénic outflow jets. This is only possible when MAVEN passes near the reconnection diffusion region. In the case of the crustal fields, SWEA measurements are used to validate field topology using electron pitch angle distributions [e.g., 6]. Particle flux can then be used to quantify the plasma exchange facilitated by the reconnection events.

By comparing the accepted events with the total number surveyed, we are able to estimate the frequency of dayside reconnection. Additionally, in order to understand which parameters are responsible for the onset of reconnection, we test the dependency of the dimensionless reconnection rate, calculated from B_N measurements, on magnetic field shear angle and plasma β (the ratio of plasma pressure to magnetic pressure). Studies at other planets have shown that reconnection efficiency is β-dependent [12, 13];

therefore, magnetosheath properties may have a large impact on the occurrence of reconnection at Mars.

Global Application: To assess the global impact of reconnection on Mars' induced magnetosphere, we combine analytical models with observations to predict the regions where reconnection may occur. Observed field orientations from MAVEN's single point measurements, both in the induced magnetosphere and the magnetosheath, are draped around the obstacle based on analytical models [14]. With this approach, the effects of IMF orientation, magnetosheath parameters, and even planetary season on reconnection may be examined on a global scale.

Summary: We present a study of magnetic reconnection at the dayside magnetosphere of Mars using MAVEN magnetic field and plasma data. Reconnection between the IMF and the Martian induced and crustal magnetic fields play an important role in the transport of flux throughout system. With the aid of analytical models we are able to assess the role of reconnection on a global scale to better understand which factors drive these dynamics in the space environment of Mars.

References:

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