URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Magnetic Field Fluctuations from the Solar Wind to the Surface of Mars

T. Esman*(1), J. R. Espley (2), J. R. Gruesbeck (2),
J. Giacalone(3), and A. Halford(2)

(1) NASA Postdoctoral Program Fellow, Goddard Space Flight Center, Greenbelt, MD, USA; e-mail: Teresa.esman@nasa.gov
(2) NASA Goddard Space Flight Center, Greenbelt, MD, USA
(3) Lunar and Planetary Laboratory, University of Arizona, Planetary Sciences, Tucson, AZ, USA

The magnetic environment of Mars is a complex and unique mix of draped interplanetary magnetic fields and localized crustal magnetic fields. The ionosphere of Mars provides an obstacle to the solar wind, which results in an induced magnetosphere. Above the ionosphere of Mars is an extended neutral exosphere which is readily ionized and these ions are picked-up by the solar wind. The interaction with the solar wind is important for understanding all layers of the Martian atmosphere. Methods were developed for identifying and characterizing magnetic waves at a range of frequencies and altitudes. An analysis of waves from ~130 km out to around 14 Mars radii was conducted to investigate exospheric escape, energy transfer, and variability of the ionosphere.

The properties and variability of the ionosphere are vital for understanding the overall atmosphere of Mars. The presence and properties of waves provide plasma and magnetic environment information. We conducted a search for 5 - 16 Hz signals below 400 km in magnetic field data from Mars Global Surveyor (MGS), the Mars Atmosphere and Volatile Evolution (MAVEN), and Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport (InSight) missions.

We discuss an analysis of 54 ionospheric events using multiple MAVEN instruments [1,3]. Stronger crustal magnetic field regions have fewer events and may be a result of stronger crustal fields preventing draped field lines from reaching lower altitudes. A majority of the observed magnetic waves occur on the nightside, are associated with greater fluxes of electrons traveling downward along the local magnetic field compared to those traveling upward, and correspond to increases in thermal plasma density. These aspects indicate electron precipitation was present during these wave events. We conclude that these waves are observed under magnetic field conditions favorable for the penetration of electrons and waves into the lower ionosphere, but that the electron precipitation cannot solely account for the waves or plasma changes.

We then discuss our null results regarding Schumann resonances, which are electromagnetic signals generated by lightning that, if they exist on Mars, are expected to propagate at 7-14 Hz [1]. Future studies specifically looking for Schumann resonances will require higher sensitivity instruments and would benefit from additional missions that reach into the ionosphere of Mars. We comment on the inconsistency between identifying MGS events purely via by-eye analysis versus using quantitative methods for guidance.

In the distant plasma region around Mars, waves are identified out to 14 Mars radii [1,2]. One population is shown to require the presence of the planet as either a source or amplifier, while another is from the solar wind. The transition from the solar wind to the ionosphere of Mars (~400 km) is still poorly understood. Future studies are encouraged to better understand the energy transfer that occurs through the layers of Martian atmosphere and the potential relationships between distant waves and low altitude waves.

References

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