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InSight Observations of Magnetic Pulsations on Martian Surface: Initial Findings and Implications

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Abstract

The InSight fluxgate magnetometer has detected magnetic pulsations on the surface of Mars for the first time. The observations have implications to the wave sources in the induced magnetosphere and whether and how these waves can reach the surface.

1. Introduction

InSight is the first Mars surface mission that carries a magnetometer, making Mars the third planetary body, after the Earth and the Moon, that has made surface magnetic field measurements. The measurements from the InSight FluxGate (IFG) magnetometer experiment are being examined to investigate the strength and variations of the surface magnetic field at the landing site [1, 2].

One of the research topics that can be studied by using the IFG observations is magnetic pulsations. With frequencies in the ultra-low-frequency (ULF) band that spans between 1 mHz and 1 Hz, many types of magnetic pulsations have been observed on the terrestrial surface. All the terrestrial magnetic pulsations have origins in the outer space, including the ionosphere, the magnetosphere, and the solar wind. The observation of each type of magnetic pulsations can often imply the occurrence of a specific physical process above the atmosphere [3].

Past and ongoing Mars orbiter missions have observed several types of magnetic pulsations near the planet, such as the upstream waves excited by back-streaming ions from the bow shock [4], impulsive oscillations associated with magnetic reconnection or flux ropes in the induced magnetotail [5, 6], and the Kelvin-Helmholtz instability that occurs due to the shear flow between the solar wind and the induced magnetosphere [7]. Only magnetic field measurements at the ground level can confirm whether any of these waves can reach the surface of Mars.

Understanding the nature of magnetic pulsations on Mars can contribute to the knowledge needed for electromagnetic sounding (EMS) of the planetary interior. Because waves at the ULF frequencies provide the input energy for the EMS of the Martian crust and mantle, identifying the sources and propagation of these waves is useful for establishing proper boundary conditions in future EMS investigations on Mars.

2. IFG measurements

We study the IFG data that begin on November 30, 2018 to examine whether and what types of magnetic pulsations are present on the Martian surface. Most of the continuous pulsations (Pc) found are in the nightside with frequencies of the order of 10 mHz. Pc at frequencies of the order of 1 mHz has also been seen in local morning.

3. Comparison with other measurements

Because the IFG sensors are mounted on the lander, we consider scenarios where non-magnetic variations in the surroundings could result in the observed oscillations in the IFG data. For example, a wind-driven twist of the lander causes a directional change of IFG sensors and possibly deviations in the IFG readings, depending on the orientation and magnitude of the ambient magnetic field. Any motion of the metal parts near the magnetic sensors could produce

signatures in the IFG data. We have examined the data from InSight's Temperature and Wind for InSight Subsystem (TWINS) and Pressure Sensor (PS) but have not found any indication that atmospheric variations are the source of the observed pulsations in the IFG data. No lander activity was found responsible for the nighttime pulsation events either.

We have also examined the observations by MAVEN during some of the strongest pulsation events seen by IFG to date. In the first two months of InSight's operation, the apoapsis of the MAVEN orbit was on the sunward side of Mars in the solar wind. The simultaneous InSight-MAVEN observations suggest that the upstream waves in the solar wind do not produce similar signatures on the Martian surface. The apoapsis of the MAVEN orbit will soon move to the nightside of Mars, facilitating the comparison between surface and orbital measurements for nighttime pulsation events.

4. Discussion

We present initial results concerning the magnetic pulsations observed by InSight. The nighttime continuous pulsations found by IFG are unexpected because they are distinct from what are typically observed on the Earth's surface at the same local time. On the other hand, we have not found the Mars counterparts for many types of geomagnetic pulsations well known in Earth studies. We speculate that the observed magnetic pulsations by InSight to date are associated with fluctuations in the induced magnetotail and on the magnetospheric boundary. Under this scenario, the distinct field and plasma environment at Mars raises interesting questions about how these oscillations propagate through the magnetosphere and ionosphere and reach the surface.

Acknowledgements

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