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Electromagnetic wave analyzer module for the ExoMars 2020 surface platform

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Abstract

The ExoMars 2020 Surface Platform will conduct environmental and geophysical measurements with the aim to study the Martian surface and subsurface environment at the landing location. The Surface Platform instrumentation will include the Wave analyzer module, consisting of an assembly of magnetic and electric antennae and dedicated electronics, as a part of the Martian ground electromagnetic tool instrument. Science questions which we plan to address have never been answered by direct observations on the surface of the planet.

1. Introduction

Recent observations of the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission on the Mars orbit have shown plasma waves [1] similar to those observed in the Earth's magnetosphere [2].

Although no experimental proof exists up to now, analogy with penetration of whistler mode waves through the Earth's ionosphere [3] and theoretical considerations [4] indicate that these waves might penetrate to the surface of Mars during night time.

By analogy with the terrestrial dust storms and volcanic eruptions [5] it can be theoretically expected that dust grains in the Martial dust storms or dust devils may be electrically charged by triboelectric effects [6]. Laboratory experiments also show that under specific conditions electrostatic discharges might occur in the dusty Martian atmosphere [7].

These discharges would emit broadband electromagnetic emissions [8] which have also been found in the laboratory experiments [9]. Moreover, remote measurements from the Earth using a 34-m Deep Space Network antenna have shown a non-thermal component of electromagnetic radiation from Mars which has been attributed to the effects of electrostatic discharges in the dust storms [10]. Measurements of effect of terrestrial dust devils have also shown a detectable electromagnetic radiation [11].

The subject, however, remains controversial. No optical counterparts of the electrical discharges inside the images of Martian dust devils and dust storms have been identified up to now, and sprite-like discharges above the dust devils or dust storms will most likely be absent on Mars [12].

Additionally, observations of the radar receiver onboard the Mars Express spacecraft [13] lead the instrument team to a conclusion that no credible radio signals between 4 and 5.5 MHz coming from Martian lightning could be detected, although the receiver would be able to easily detect terrestrial lightning. These results, however, did not rule out the possibility of discharges that radiate at much lower or at much higher frequencies.

2. Science questions

The following science questions stem from previous research and will be addressed by the Wave analyzer module on the ExoMars 2020 surface platform:

A. Can we observe electromagnetic radiation propagating from the interplanetary space down to the surface of the planet? If yes, then

A1. Which frequencies and plasma wave modes can penetrate down to the surface of Mars?

A2. What are the conditions under which we observe the penetration of electromagnetic radiation from interplanetary space down to the surface of Mars?

A3. What state of the Martian ionosphere is the most favorable for the penetration to happen?

B. Can we observe electromagnetic radiation from electric discharges in the Martian dust storms? If yes, then:

B1. Are the waveforms of the electromagnetic radiation from Martian discharges similar to the waveforms radiated from the terrestrial lightning?

B2. Which processes lead to initial break-down of Martian discharges and how are these processes reflected in the detectable electromagnetic radiation?

B3. Which special meteorological conditions lead to initiation of Martian discharges?

To address all these questions a statistical analysis of a sufficiently long time series of electromagnetic measurements on the surface of Mars would be needed.

3. The wave analyzer module

Electromagnetic waves will be measured by the sensor assembly of the module which will be integrated with one of the solar panels of the Surface platform: a magnetic search coil antenna for frequencies up to 20 kHz and additional electric antenna for frequencies up to 8 MHz.

The electronics of the module will then use sophisticated onboard analysis methods in order to maximize the scientific return with the limited telemetry resources by science-based compression.

The data products will include time and frequency averaged survey mode spectra of electric and magnetic field, high-resolution burst mode spectra, and selected high-resolution waveform burst mode snapshots.

Onboard storage mechanisms and selective download, as well as triggering and selection algorithms will be adjustable by telecommands.

Autonomous nigh-time operations are proposed to increase the detection probability of waves propagating through the ionosphere. A positive side effect is absence of interferences from solar panels.

References

[1] Harada, Y., et al. (2016), MAVEN observations of electron-induced whistler mode waves in the Martian magnetosphere, J. Geophys. Res. Space Physics, 121, doi:10.1002/2016JA023194.

[2] Santolik O. and J. Chum (2009), The origin of plasmaspheric hiss, Science 324, 5928, 729-730.

[3] Santolik, O. et al. (2009), Propagation of unducted whistlers from their source lightning: a case study, J. Geophys. Res., 114, A03212, doi:10.1029/2008JA 013776.

[4] Melnik O., and M. Parrot (1999), Propagation of electromagnetic waves through the Martian ionosphere, J. Geophys. Res. 104, 12705-12714

[5] Antel, C., et al. (2014), Investigating Dunedin whistlers using volcanic lightning, Geophys. Res. Lett., 41, 4420–4426,doi:10.1002/2014GL060332.

[6] Melnik O., and M. Parrot (1998), Electrostatic discharge in Martian dust storms, J. Geophys. Res. 103, 29107-29117.

[7] Krauss et al. (2003), Experimental evidence for electrostatic discharging of dust near the surface of Mars, New Journal of Physics 5 70.1–70.9.

[8] Renno et al. (2003), Electrical discharges and broadband radio emission by Martian dust devils and dust storms, Geophys. Res. Lett., 30(22), 2140.

[9] Aplin et al. (2011), Measuring Martian lightning, Journal of Physics: Conference Series 301 012007 doi:10.1088/1742-6596/301/1/012007

[10] Ruf et al. (2009), Emission of non-thermal microwave radiation by a Martian dust storm, Geophys. Res. Lett., 36, L13202, doi:10.1029/2009GL038715.

[11] Farrell et al. (2004), Electric and magnetic signatures of dust devils from the 2000–2001 MATADOR desert tests, J. Geophys. Res., 109, E03004, doi:10.1029/2003JE002088.

[12] Yair et al. (2009), A study of the possibility of sprites in the atmospheres of other planets, J. Geophys. Res., 114, E09002, doi:10.1029/2008JE003311.

[13] Gurnett et al. (2010), Non‐detection of impulsive radio signals from lightning in Martian dust storms using the radar receiver on the Mars Express spacecraft, Geophys. Res. Lett., 37, L17802, doi:10.1029/2010GL044368.