EPSC Abstracts
Vol. 10, EPSC2015-508, 2015
European Planetary Science Congress 2015

Micro-Ares, An electric field sensor for ExoMars 2016

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Abstract

For the past few years, LATMOS has been involved in the development of Micro-ARES, an electric field sensor part of the science payload (DREAMS) of the ExoMars 2016 Schiaparelli entry, descent and landing demonstrator module (EDM). It is dedicated to the very first measurement and characterization of the Martian atmospheric electricity.

1. Introduction

The Martian atmospheric electric fields are suspected to be at the very basis of various phenomenon such as dust lifting [1][2][3], formation of oxidizing agents [2][4] or Schumann resonances [5]. Although the data collection by DREAMS will be restricted to a few days of operations, these first results will be of importance to understand the Martian dust cycle, the electrical environment and possibly relevant to atmospheric chemistry. The instrument, a compact version of the ARES instrument for the ExoMars Humboldt payload [6], is composed of an electronic board, with an amplification line and a real-time data processing DSP, which handles the electric signal measured between the spherical electrode (located at the top of a 27-cm high antenna) that adjusts itself to the local atmospheric potential, and the lander structure, connected to the ground.

Figure 1 : Micro-ARES antenna and board

2. Scientific goals

Although the Martian electric activity has never been observed, the interest of the scientific community has been ever growing during the past ten years since they should be responsible for various phenomenon such as:

- The existence of a Martian global electrical circuit where dust-devils and dust storms are the generator and the ionosphere ($\sigma \approx$ 1S/m), conductive atmosphere ($\sigma \approx 10^{-11}$ S/m) [7] and ionized ground are the circuit, where significant currents could flow.
- The Martian dust cycle, which most impressive manifestations are the annual global dust storms, is suspected to be intrinsically linked to the electric-field since very simple calculations shows that the aerodynamic and electrostatic forces on dust grains are of the same order of magnitude [1][2][3][6].
- The atmospheric chemistry is also believed to be highly affected by the creation of energized free electrons which lead to the fabrication of oxidizing agents (O^-, OH^- or H_2O_2) [2][4] which could efficiently remove organic materials.
- The same way electromagnetic waves appear in the Earth-ionosphere cavity, those waves, called Schumann resonances, could appear on Mars [5][8], bringing new insights about the peculiar Martian ionosphere.

3. Field test campaign

The field measurement in Martian-like conditions, at least in terms of meteorological events, had to be performed in order to prove the good behaviour of Micro-ARES and it ability to retrieve the necessary scientific data. Those tests have been carried out in July 2014 in Moroccan Sahara desert, in parallel with DREAMS-like instruments (wind speed, pressure, hygrometry, temperature, optical depth at least) and above all, another electric-field measurement device, properly calibrated, which has been used as a reference for comparison. The main difference between the Earth and Mars surface atmosphere is the atmospheric conductivity, which is about two orders of magnitude higher on Mars. Therefore, the antenna had to be adapted so that the input electronics of Micro-ARES could behave the same way it will on Mars.

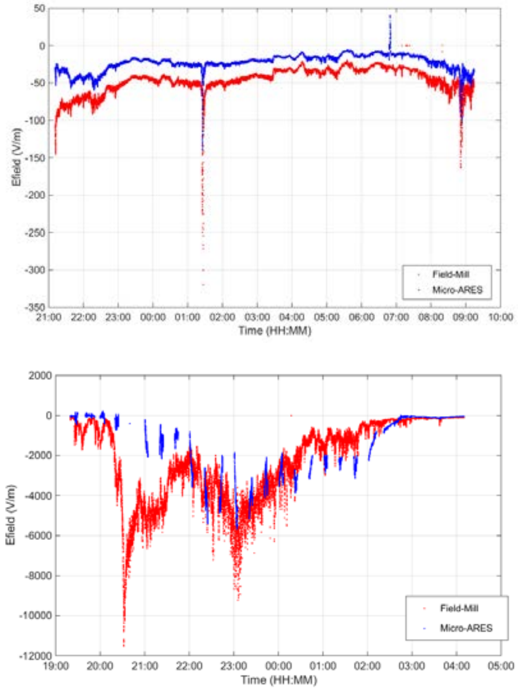

Figure 2 : Calm and Storm wheather comparison between Field mill (red) and Micro-ARES(blue)

This test campaign shew a very high correlation between the data acquired by Micro-ARES and the one harvested by the Field-mill, the main differences being caused by their different installation height (2m vs. 80cm from the ground). The instrument has even been able to measure the Earth Schumann resonances, despite their very low amplitude (100^{th} of µV/m). This campaign has therefore been very conclusive in regards to the ability of the instrument to collect the necessary data in order to answer, at least partially, the questions raised in §2.

4. Martian chamber test campaign

In order to confirm or adjust the antenna-atmosphere coupling model [9], which is capital for the proper data processing, it has to be tested in a Martian atmospheric chamber (CO_2 atmosphere, cooled down to temperatures around -100°C) which is available at LATMOS.

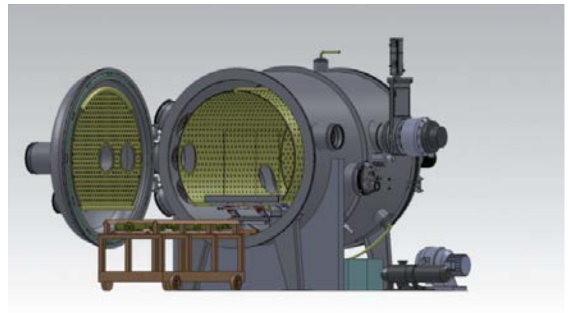

Figure 3 : 60x60x60 climate chamber

The test will be performed in the chamber with the adequate atmosphere and an ionizing device (UV LEDs or Corona effect generator) in order to bring up the conductivity to the ones we expect on Mars [7], and the antenna placed between two metallic plates where the electric field generated can reach up to 24kV/m. In order to make the electric field uniform between the plates, several metallic hoops will be placed around the antenna, between the plates, with their potentials linearly evolving. These tests, combined with a precise electric modelling of the lander, will help to fully understand and quantify the electric field deformation around the lander and properly process the data gathered by Micro-ARES.

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