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Comet Siding Spring's influence on Mars' ionosphere at its closest approach

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Abstract

On October 19th 2014, Mars experienced a close encounter with Comet C/2013 A1 (Siding Spring), at a distance of 141,000 km. The coma washed over Mars and the planet passed directly through the cometary debris stream, producing significant effects in Mars' upper atmosphere. We present here an overview of ionospheric measurements performed during the 10h that Mars was in the coma from the MARSIS radar on board Mars Express. We discuss the comet's influence on the ionosphere through different processes like dust attachment, water molecule recombination, and cometary magnetic field.

1. Geometry and timing of the comet encounter

The closest approach with comet Siding Spring took place at a distance of 141,000 km, on 19 October 2014 at 18:28 UT (Solar longitude Ls 217, Martian Year 32). It flew by Mars at a relative velocity of 56 km/s, moving from South to North (retrograde orbit, 129 degrees inclination).

2. Space weather context

This unique event allows us to investigate the response of Mars' upper atmosphere to such a rare encounter, as this may have implications for overall atmospheric evolution. However, the conditions were very complex due to significant space weather disturbances, which makes the distinction between space weather and cometary effects on the Martian plasma system difficult to assess.

The cometary encounter was somehow masked by the transit of a powerful Coronal Mass Ejection (CME) 44 hours before [1]. Consequently, the comet flyby took place when the Martian plasma system was still recovering from the CME impact, whilst the solar wind passing Mars remained significantly disturbed. This is also observed through the large amount of cometary energetic particles that precipitated over Mars during this time [2].

3. Data sets

In this study we use data from the MARSIS radar aboard Mars Express in the active ionospheric mode [3] which give access to local electron densities at the spacecraft altitude, electron density profiles and an indication of the signal attenuation (due to electrons present at low altitudes [4]).

4. Effects on Mars' ionosphere

The interaction of the Siding Spring coma and the Mars' ionosphere can be characterized by several processes. First, the magnetosphere was severely distorted during the comet's passage [5]. As a consequence, we can expect some disturbances in the topside ionosphere. A second effect is the flux of pickup O^+ ions originating from the coma interacting with the solar wind. These pickup ions precipitate primarily on the dayside hemisphere and can increase ionospheric densities around 110-120 km altitude [2]. Finally, cometary dust and a large amount of water species were deposited in the atmosphere, and seem to have an effect (a large density reduction) on the behavior of the ionosphere of Mars (Figure 1).

These mechanisms and effects will be discussed and compared, with the support of modeling and data

analysis. In particular, we will attempt to explain ionospheric compressions and bulges observed in the Mars Express data set (see Figure 1), and explore the complex dust-ionosphere interaction.

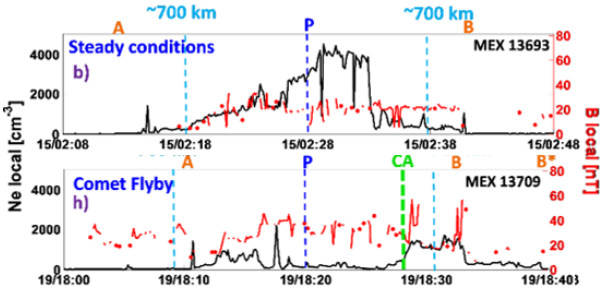

Figure 1: *MARSIS local plasma observations of the ionosphere of Mars at MEX altitude for steady conditions (upper panel) and for the orbit of closest approach (CA, bottom panel). Each panel shows local electron density (in black) and local magnetic field (in red).*

Acknowledgements

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