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Space Weather Conditions Before, During and After the Comet Siding Spring Encounter with Mars

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Abstract

On October 19th 2014, Comet C/2013 A1 (Siding Spring) passed Mars at a distance of 138,000 km. The resultant interaction as the planet passed through the coma and the cometary debris stream produced significant effects in the Mars' upper atmosphere. However, before, during after the closest approach, there were significant space weather events which make the interpretation of the observations difficult. Here we summarise these events such to aid any subsequent attempts at determining the exact nature of the interaction between comet and Mars' upper atmosphere.

1. Introduction

Comet C/2013 A1 (Siding Spring) approached Mars on the 19th October and closest approach occurred at 18:28 UT that day. The coma entirely engulfed the planet while the tail also washed over the planet. There were a number of spacecraft either in orbit around, or at the surface of Mars during the encounter. These spacecraft included Mars express (MEX), Mars Atmosphere and Volatile Evolution (MAVEN), Mars Reconnaissance Orbiter, Mars Odyssey, and the Curiosity Rover. While not all instruments were switched on during the encounter, there is a substantial data base of observations before during and after the encounter. Here we provide an overview of the space weather events which occurred before, during and after the cometary encounter with Mars, with the aim of providing a general understanding of the background conditions under which the encounter took place. In many respects this interval was one of the most disturbed of the current solar cycle.

2. Timeline of events

We start by providing a simple timeline of events as they occurred at Mars. We divide the background conditions into three separate types of events, a co-rotating interaction region (CIR), coronal mass ejections, and solar flares. Each of these events elicits a different response at Mars.

Based on the observations of solar wind velocity by the ASPERA-3 instrument on MEX, the first CME to impact at Mars was launched on 13th October from the sun, and reached Mars on the 16th October. A larger CME was launched the following day from the sun and arrived on the 17th October. This has proven to be one of the largest CME of the current solar cycle. This second event has in fact been seen at a number of different locations throughout the solar system [1], from Mercury orbit out to possibly New Horizons close to Pluto. At the time of the CME the solar wind velocity at Mars reached 700 km s-1, based on ASPERA data. Multi-spacecraft observations are complemented with a dedicated WSA-ENLIL+Cone (large-scale, physics-based prediction model of the heliosphere) solar wind simulation, in which this CMe has been included. Further, based on the RAD instrument on Mars Science Laboratory on the Curiosity Rover and Mars Odyssey HEND data, the galactic cosmic ray intensity reduced by some 20% of the peak value just after the CME arrival at Mars [1]. Comparison with other CME events at Mars using the same HEND instrument suggests that they typically result in reductions by about 5% of the peak value prior to CME arrival.

Further during the interval of interest, a number of solar flares were detected which would have impacted on Mars. One of the largest of these was an X1.1 flare which impacted at Mars on the 19th October just prior

to the cometary encounter [2]. The largest flare, an X1.6 flare, impacted at Mars on 22nd October several days after the cometary encounter, although it is important to understand that the Martian system may at that time have been still recovering from the encounter.

Four M class flares were also launched in the direction of Mars during the interval. An M1.1 class flare was launched at the same time as the second CME on 14th October, while a M1.6 class flare was launched on 18th October, the day before the cometary encounter. Finally, 2 were launched on 22nd October, one a M8.7 class flare and another a M2.7 class flare. There were also some 20 C class events which may have impacted on Mars, but these are not detailed here as their effect is likely to have been smaller, although we will still analyse the effects of these where possible.

3. Summary

In summary the interval before, during and after the Siding Spring encounter with Mars was one of the most disturbed periods of the current solar cycle. Therefore, it is important to understand the impacts of these events in order that we can separate out the cometary effects from space weather effects.

Acknowledgements

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References

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