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SEPs effect on the Venusian plasma environment

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Abstract

A fast coronal mass ejection from the Sun often produces solar energetic particles that travel at a large speed along the interplanetary magnetic field lines. If the magnetic field lines are connected to Venus, the solar energetic particles will arrive before the interplanetary coronal mass ejection. In this presentation, we will elaborate on the potential effect of the SEPs on the Venusian plasma environment from the ion measurements by the Venus Express mission.

1. Introduction

The interaction between the solar wind and Venus upper atmosphere creates an induced magnetosphere, which allows Venus to withstand the direct pressure of the incoming solar wind. Nonetheless, the interaction with the solar wind causes an escape of particles from the Venusian upper atmosphere [3]. During extreme events, such as when an Interplanetary Coronal Mass Ejection (ICME) arrives at Venus, the escape rate in the magnetotail increases [2], and the pick-up ions are accelerated at a larger rate [6]. Often, when a fast CME occur at the Sun, solar energetic particles (SEPs) are emitted, which follows the interplanetary magnetic field at very high speeds, and reach Venus after a few hours. The ICME shock front travels at lower velocities and only arrives after a few days (see review in [8]). Therefore, if the SEPs are emitted along a magnetic field line that is connected to Venus, we expect an additional effect on the Venusian space environment. Modelling efforts have shown that the SEPs will increase the ionization of atmospheric particles in the lower ionosphere, below the ionization peak of the nominal solar radiation [7]. In addition, at Mars, UV measurements from the MAVEN mission showed that the arrival of SEPs caused aurora in the atmosphere [9], and an increase in upward flux of super-thermal secondary electrons [5]. For Venus, there has not yet been any joint measurements of the arrival of SEPs and auroral emissions from the atmosphere. However, Earth-based visible measurements indicate that CME impacts drive auroral emission in the nightside atmosphere [4]. Therefore, further investigations of the effect on the atmosphere from SEPs are needed. If the difference in the time of arrival of SEPs and the ICME is large, the effect on the plasma environment from the two parts can be investigated separately using in situ plasma measurements. In this study, we have found a few cases of when the SEPs arrive about one day before the ICME and our aim is to extract the potential measurable effects of the SEPs on the Venusian plasma environment.

2. Data and method

We use the Ion Mass Analyser (IMA) instrument, part of the ASPERA-4 instrument package [1] on board the Venus Express mission [10] to observe changes in the plasma environment. The instrument measures ions with a field-of-view of 90x360° and energies 0.01-36 keV/q in 192 s. The mass-separation capability of the instrument can separate out the heavy ions from the lighter.

To find space weather events we use the background counts of the IMA instrument. The background counts are measured in a region of the microchannel plates where the nominal measurements do not reach, and instead this region measures particles with very high energies that penetrated the instrument, such as SEPs.

We have identified nine space weather events where the SEPs were measured by the IMA background channels between 2011-2014. These events have clear signatures of SEPs arriving at Venus about one day before the interplanetary coronal mass ejection (ICME). We then use the IMA measurements of the heavy ions to investigate any change in differential flux at different energies.

3. Preliminary results

We have so far found one event where the low energy differential flux in the Venusian ionosphere increases right after the arrival of SEPs, which may be due to the impact ionization from the precipitating SEPs. Later when the ICME shock front reaches Venus, the low energy differential flux decreases and the high energy differential flux increases, indicating acceleration of the ions already existing in the ionosphere leading to a higher escape, in agreement with previous results [2].

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