EPSC Abstracts
Vol. 13, EPSC-DPS2019-48-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Modeling the impact of an X-class solar flare on the exosphere of Mercury

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Abstract

The weak magnetic field, tenuous atmosphere and close distance from the Sun makes Mercury more susceptible to solar transients than other terrestrial planets. For this reason short-term variations in Mercury's sodium exosphere have been associated with the passage of coronal mass ejections (CMEs) [5, 2, 4] and solar flares [1]. Helium ion enhancements have also been recently observed as the direct result of a CME arrival [6].

In this first work we simulate the response of Mercury's exosphere to an X-class solar flare. The momentaneous increase in the extreme ultraviolet (EUV) photon flux during a solar flare functions well as a proxy for modeling the response of the exosphere to extreme variations in the external plasma conditions. This test will allow us to extend such short-term time variations to model the impact of a CME on the precipitation of sodium and other species in Mercury's coupled exosphere-magnetosphere system.

We employ the Exospheric Global Model (EGM) [3], a 3-D parallelized Monte Carlo model, to model Mercury's exosphere. In this model, 10^7 test-particles with statistically representative weights are ejected at the start of the simulation and then followed as they move in the exosphere on ballistic trajectories. These particles can escape from the exosphere, stick to the surface or be re-ejected through one of four processes: thermal desorption (TD), photo-stimulated desorption (PSD), solar wind sputtering and meteoroid vaporization.

We investigate the flare-induced effects on the release of several exospheric species, including sodium and helium, through PSD, TD and photo-ionization. In addition, we will present simulation results with a test-particle model capable of tracing the trajectories of newly created ions as they leave the exosphere and enter the magnetosphere.

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