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Phobos' regolith interaction with the martian environment

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1. Introduction

Phobos and Deimos origins are still under debate and although formation from a debris disk following a impact seems plausible [1], other scenario such as captured objects cannot be ruled out (see [2,3] and references therein). In the case of Phobos, the latest observations in the thermal infrared range are consistent with the presence of phylosillicates, iron bearing compounds as well as mixed silicate-carbonate components and surface hydration from unclear origin [4,5]. Those observations do not allow to discriminate between different formation scenarios.

Through sputtering of the moons surfaces by solar wind, pick-up and planetary ions, surface material is continuously released in the martian environment with species somehow indicative of the moon regolith' composition.

Assuming an Iron rich composition typically matching that of D-types asteroids [6,7], production rates for Iron and Magnesium of respectively 3.04×10^{16} atoms.s^{-1} and 2.58×10^{16} atoms.s^{-1} were estimated for solar minimum conditions [8], driven mainly by solar wind ion sputtering. Pick-up ions of planetary origin have since then been reported as possibly resulting in larger sputtered fluxes under certain conditions [9].

In the present study, we simulate the sputtering of Phobos's regolith by solar wind and planetary ions for various IMF and crustal field configurations, and solar activity conditions corresponding to January to June 2015 period (F10.7 index 130). We also include ionization of the ejected neutrals by electron impact, solar photon impact, and charge exchange reactions with solar wind protons.

2. Methods and Outputs

We use a 3D Monte Carlo Test-particle numerical approach as described in [8] and references therein in order to simulate sputtering from Phobos' surface along the moon's orbit. Ejected neutrals are subject to electron impact ionization, UV solar photon impact ionization, and ionization by charge exchange with solar wind protons .

The magnetic and electric field environment at Phobos' orbit is extracted from a global multi-species parallel hybrid simulation model (LatHyS). Moreover, the model characterizes the precipitation solar wind and planetary ions (H^+ and O^+) at Phobos' surface. Simulations are performed with a spatial resolution of 80 km, however the full distribution function of the plasma in position and velocity space is provided on a uniform cartesian grid with 160km resolution. These information are used and interpolated into our test-particle simulation ~~grid~~ model. Additionally, the Martian crustal field is also modelled and might influence the planetary ions distributions at Phobos orbit.

Solar wind ions velocities and densities, IMF conditions, convection electric field, as well as planetary ions inputs (H^+ and O^+) are provided by a Hybrid model of the solar wind interaction with Mars [10], with a grid resolution of 160km which is interpolated to our test-particle simulation grid. Additionally, the martian crustal field is also modelled, as it may influence the planetary ion distributions at Phobos' orbit.

While neutral particles motion is subject to the gravity of Mars and its moons, as well as solar radiation pressure, newly created ions are picked –up by the convection electric field of the solar wind. Neutrals and ions are followed in the model until they escape the simulation domain or are lost to Mars.

We study the sensitivity of the ejected neutral clouds and of pick-up ions fluxes to the IMF and crustal field configurations, and compare our results with previous estimates. We also provide expected fluxes for major species of interest (Fe / Fe^+ and Mg / Mg^+ along Mars Express and MAVEN orbits, during close flybys with Phobos, and discuss possible analysis of data from these two spacecraft

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