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Modelling backscattered hydrogen distribution at Phobos' orbit

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Abstract

We study backscattering of Solar Wind protons by Phobos' regolith from the modelling point of view. We carry out simulations of ejected ionized and neutral hydrogen atoms populations. Our calculations will help interpretation of current and future observations of such populations.

1. Purpose of the Study

MAP-PACE/SELENE measurements[1] allowed detection of Solar Wind protons reflected by the lunar regolith. A similar process seems to lead to a significant reflected flux of neutral hydrogen atoms (up to 20% of the impinging Solar Wind protons flux), as evidenced by SARA/Chandrayaan-1 measurements [2].

Similarly to the Moon, Phobos' surface is weathered by micrometeoroids impacts and Solar Wind ions bombardment. Since a significant part of Phobos' orbit is exposed to the shocked Solar Wind, downstream of the Martian Bow Shock, a SW protons reflection process similar to that observed at the Moon is likely to occur, as suggested by IMA/ASPERA-3 data (Ion Mass Analyzer) [3].

In the present study we simulate SW protons backscattering process by using a 3D Test Particle model previously developed to study neutral atoms ejecta cloud morphology at Phobos' orbit [4].

2. Simulation / Expected Results

We use electric and magnetic field values within 2.5 Martian radii (including Phobos' orbit) given by a Hybrid simulation performed in low solar activity conditions [5], in order to follow reflected protons trajectories over a large scale.

Backscattered particles leave the surface either as ions (reflected protons) or neutrals (neutralization occurs at the surface) resulting in two distinct reflected populations. Both populations are subject to Martian gravity and to the solar radiation pressure.

Such reflected particles are assumed to leave Phobos' surface with energies up to about 40% of Solar Wind protons energies, consistently with observations made at the Moon and at Phobos.

Since Phobos' surface electrostatic charging state may influence protons trajectory in Phobos vicinity, as well as the charge state of ejected atoms, we introduce an electrostatic potential boundary condition at Phobos' surface in the simulation.

Ejected neutrals on the one hand, and protons on the other hand, are followed around Mars, and can be lost into the Martian thermosphere, or when escaping the system.

Specifically, reflected protons can be neutralized through charge exchange reactions with exospheric oxygen atoms leading to an ENA signature on the one hand, and reflected neutrals can be ionized by photons or electrons impact, or charge exchange reactions, leading to a proton signature, on the other hand.

We use this model to derive estimates of backscattered fluxes and describe their spatial distributions around Mars.

Dependence of the reflected protons and neutrals populations, on the IMF characteristics and Phobos' surface potential will also be described.

References

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