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CME impact on Mercury's sputtered exospheric environment

M. Pfleger (1), H.I.M. Lichtenegger (1), H. Lammer (1), A. Mura (2), P. Wurz (3), and J.A. Martin-Fernandez (4)
(1) Space Research Institute, Austrian Academy of Sciences, Graz, Austria, (2) Istituto di Fisica dello Spazio Interplanetario, Rome, Italy (3) Physics Institute, University of Bern, Switzerland, (4) Department for Computer Science and Applied Mathematics, University of Girona, Spain

1. Introduction

Solar wind and magnetospheric plasma precipitation onto the surface of Mercury triggers the formation of exospheric particle populations by sputtering processes. Numerical modeling of Mercury's magnetosphere has shown that the weak intrinsic magnetic field of the planet is sufficient to prevent the equatorial regions from being impacted by solar wind ions during moderate solar wind conditions. However, intense fluxes of protons are expected to hit the auroral regions, giving rise to the release of surface elements at high latitudes by ion sputtering. During high solar wind dynamic pressure conditions in the case of CME events, the solar wind protons will have access to Mercury's entire dayside surface, which may result in a considerable filling of the exosphere by sputtered surface material.

2. Model description

The density distribution in Mercury's exosphere is considered as the result of three major physical processes: (a) precipitation of solar wind protons onto the surface, (b) sputtering of surface elements, and (c) spreading of the sputtered particles around the planet.

[2] developed a numerical model to reproduce the processes of solar wind proton precipitation. The fluxes and energies of the precipitating solar wind protons are given as surface maps, i.e. as functions of latitude and longitude at Mercury's surface. Two case studies were performed: (1) normal solar wind conditions (2) CME conditions with higher solar wind densities and velocities and an enhanced He fraction. For Mercury's surface composition the multiplicative model of [3] was used (Table 1).

For each of the 60×90 surface areas corresponding to the proton flux map the fluxes and energies serve as input for calculating the sputter yields of the species of interest by means of the TRIM.SP software ([1, 4, 5]). The 3D exosphere model traces the ballistic trajectories of the released particles up to 50000 km altitude. The initial magnitude of the particle's velocity is determined by the release energy, whereas the vertical velocity component is assumed to follow a $\cos^2$-distribution; the horizontal velocity component is randomly taken from a uniform sample between 0 and 2π.

Table 1: Modeled elemental surface abundance in units of atom percent as calculated with the multiplicative composition modeling method described in [3] and used as input for the calculation of the global sputter yield distribution.

Species	O	Mg	Al	Si
Abundance	59.42	15.8	2.62	17.3
Species	P	S	Ca	Ti
Abundance	0.268	0.591	1.67	0.014
Species	Cr	Fe	Zn	
Abundance	0.041	0.611	0.285	

3 Results

A selected sample of results obtained for both a normal solar wind and CME condition is illustrated in Figure 1. This figure represents a noon-midnight meridian section, where the solar wind is blowing from right to left. As can be seen, the elements are mainly ejected from the auroral zones, where the proton precipitation is maximum. While the nightside density of sputtered particles is rather insensitive to the solar wind velocity, the dayside concentration is distinctly enhanced during high solar wind periods (right panel in Figure 1). This increase in the exosphere density is directly related to the increase in the impact intensity for CME condition.

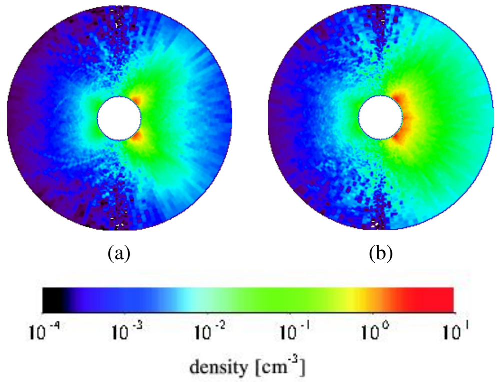

Figure 1: Meridian sections of calcium density for normal solar wind conditions (panel a) and for high solar wind conditions (panel b).

References

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