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Three-Dimensional Global Hybrid Simulations of Mercury's Disappearing Dayside Magnetosphere

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An important discovery of MESSENGER is the occurrence of dayside disappearing magnetosphere (DDM) events that occur when the solar wind dynamic pressure is extremely high and the interplanetary magnetic field (IMF) is both intense and southward. Previous observations [1,2] indicate that the extreme solar wind compression and reconnection-driven erosion of Mercury's dayside magnetosphere lead to the DDM events. Due to the limited observations from the MESSENGER spacecraft, it is difficult to study the DDM events in detail, such as the three-dimensional (3-D) shape and time evolution of Mercury's magnetosphere, as well as the ion flux precipitating on the planetary surface.

In this study, we investigate the DDM events at Mercury under extreme solar wind conditions using a three-dimensional (3-D) global hybrid simulation model. Our results show that when the solar wind dynamic pressure is 107 nPa and the magnitude of the purely southward IMF is 50 nT, most of the dayside magnetosphere disappears within 10 s after the interaction between the solar wind and the planetary magnetic field starts (left panel in Figure 1). During the DDM event, the ion flux is significantly enhanced at most of the planetary dayside surface and reaches its maximum value of about $10^{10}\,\mathrm{cm^{-2}s^{-1}}$ at the low-latitude surface, which is much larger than that under normal solar wind conditions. During the DDM events, the dayside bow shock mostly disappears for about 9 s and then reappears. Moreover, the time evolution of magnetopause standoff distance under different solar wind conditions is also studied. When the solar wind dynamic pressure exceeds 25 nPa and the IMF is purely southward, a part of the dayside magnetosphere disappears. Under the same IMF, the higher the solar wind dynamic pressure, the faster the magnetopause standoff distance reaches the planetary surface. When the solar wind conditions are normal (with a dynamic pressure of 8 nPa) or the IMF is purely northward, the dayside magnetosphere does not disappear (right panel in Figure 1).

References
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[2] R. M. Winslow et al, *Astrophys. J.*, **889**(2), 184 (2020).

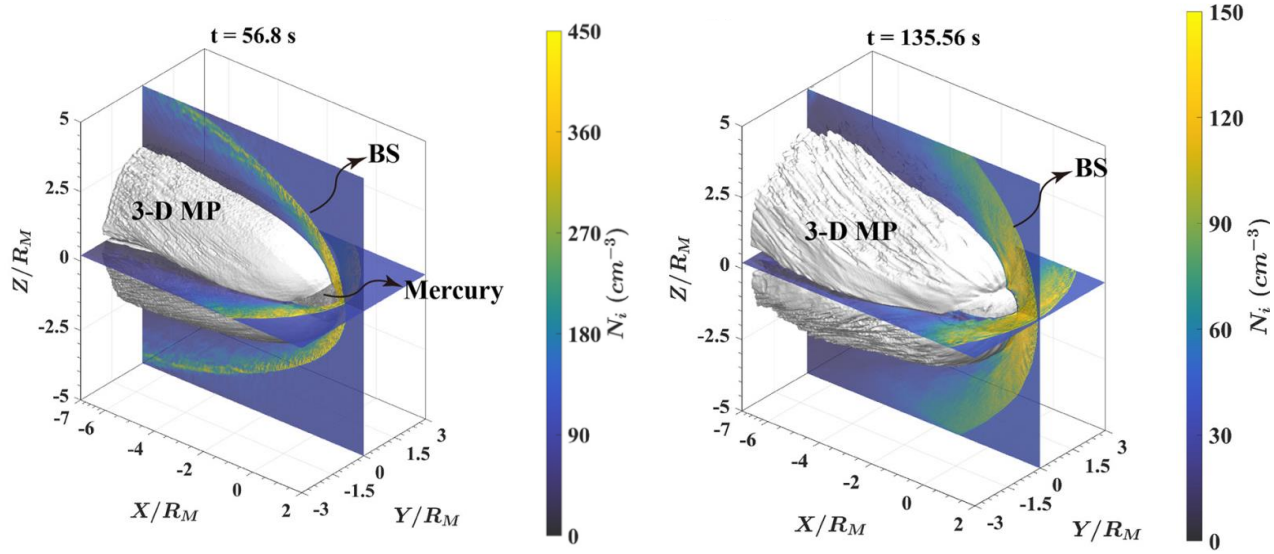

Figure 1. 3-D views of Mercury's magnetopause under extreme (left panel) and normal (right panel) solar wind conditions. The slices show the ion number density N_i in the noon-midnight meridian and equatorial planes. The 3-D magnetopause surface and Mercury are indicated by the white surface and a dark gray sphere, respectively.