Three-dimensional global hybrid simulations of flux transfer event showers at Mercury

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One of the important MESSENGER observations is the formation of flux transfer event (FTE) showers, where tens of FTEs are observed in a short time interval of about 1-2 minutes, at the Mercury's magnetopause[1,2]. In this study, we investigate the interactions between the solar wind and Mercury's magnetosphere using three-dimensional (3-D) global hybrid simulations. When the interplanetary magnetic field (IMF) is purely northward, FTE showers can be produced in both the northward and southward hemispheres of the high-latitude nightside magnetopause, and these FTEs propagate toward the magnetotail with a speed of about 250km/s. When the IMF is purely southward, we find FTE showers at the low-latitude dayside magnetopause, and these FTEs propagate northward or southward with a speed of about 90km/s. The typical FTEs have a duration of 1-2 s, and reoccur in 5-6 s. Our simulations provide a good explanation for FTE showers observed by MESSENGER.

Figure 1(a) plots the 3-D view of the Mercury's magnetosphere obtained from our hybrid simulation at $t = 127.89\ s$ in Case 1, showing the ion number density N_i in the noon-midnight meridian and equatorial planes, magnetic field lines in the noon-midnight meridian plane, and the magnetic structures of FTEs formed during magnetopause reconnection. The subsolar distance of the magnetosphere is about $1.5\ R_M$, which is consistent with the satellite observations[3]. A shock stands in front of the magnetopause, and its subsolar distance is about $1.9\ R_M$. The ion number density is enhanced in the magnetosheath. There are 6 FTEs in total at this time, with 3 FTEs in the northern hemisphere and the other 3 FTEs in the southern hemispheres of the high-latitude nightside magnetopause. In these FTEs, one end of magnetic field line is connected to the Mercury's magnetic field, and the other to the IMF in the solar wind (not shown). The magnetic structures of three FTEs (marked by "F1", "F2" and "F3", respectively) can be clearly identified in Figure 1(b), which presents the enlarged view of the denoted region in Figure 1(a). In Figure 1(c), we show three components of the magnetic field (B_x, $B_y$and B_z) and the ion number density N_i. In each FTE, the component of magnetic field B_z has a bipolar structure, and the ion number density is enhanced, which are typical characteristics of FTE

References
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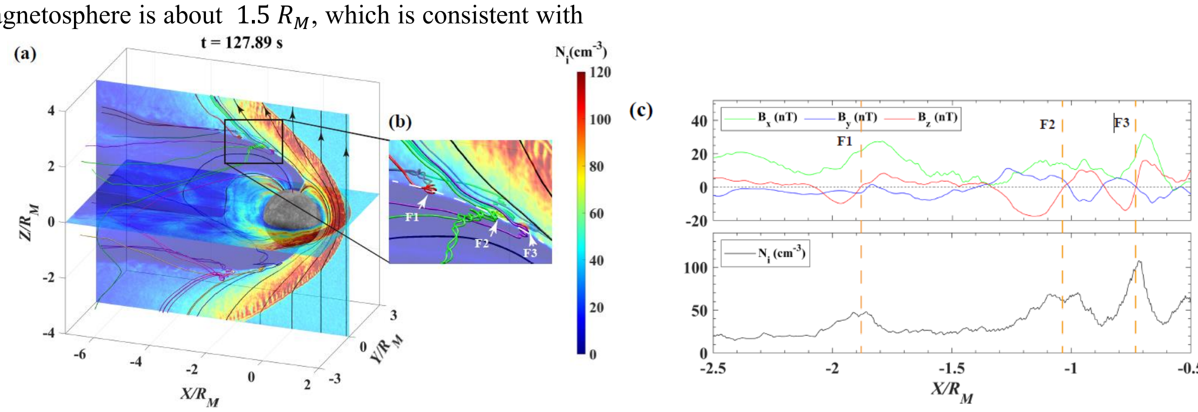

Figure 1. 3-D view of the Mercury's magnetosphere obtained from our hybrid simulation at $t = 127.89\ s$ in Case 1. (a) The ion number density N_i in the noon-midnight meridian and equatorial planes. The magnetic structure of six FTEs is represented by 3-D magnetic field lines with different colors (red, green and violet). (b) The enlarged view of the denoted region in (a), and F1-3 represent three FTEs. (c) Three components of the magnetic field (B_x, $B_y$and B_z) and the ion number density N_i along the dashed line in (b).