MHD Modeling of the Structures and Dynamics of Mercury's Magnetosphere during the MESSENGER Flybys

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The MESSENGER spacecraft flybys of Mercury on 14 January 2008, 6 October 2008, and 30 September 2009 provided a special opportunity to study the magnetosphere of the innermost planet under different solar wind and interplanetary magnetic field (IMF) conditions. In this paper, the structures and dynamics of Mercury's magnetosphere are investigated using a three-dimensional bi-fluid magnetohydrodynamic (MHD) model that solves the fluid equations for solar wind protons and electrons. With this model, we provide new estimates of the strength of Mercury's intrinsic magnetic field along with the solar wind conditions that prevailed at the time of these flybys. A comparison of the magnetospheric structures generated by northward and southward IMF shows the important role of dayside and night-side reconnections in the coupling between the magnetosphere and the solar wind. It also shows the effect of IMF conditions on the location and intensity of ion precipitation onto Mercury's surface. Moreover, analysis of the plasma flow generated by our model reveals the existence of a quasi-stable drift belt around the planet. Such a belt can account for the locations of diamagnetic decreases observed during the first two MESSENGER flybys.