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Solar wind controls on Mercury's magnetospheric cusp

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Mercury's magnetospheric cusp results from the interaction between the planetary intrinsic magnetic field and the solar wind. In this study, we assemble 2848 orbits of MESSENGER data for a comprehensive assessment of solar wind control on Mercury's cusp. We propose and validate an IMF estimation approach for the cusp transit, and construct an index to measure the magnetic disturbance. The index maximizes within the cusp, more intense than in the adjacent magnetosphere by several orders of magnitude. We develop an empirical model of the index as a function of IMFvector and Mercury's solar orbital phase. The model is used to study the cusp activity under different conditions. Comparisons reveal the cusp activity is more intense and extends further in local time, under antisunward IMF (IMFx<0) than sunward (IMFx>0), under southward IMF (IMFz<0) than northward (IMFz>0), and when Mercury orbits at its perihelion than at aphelion. Besides, the cusp shifts azimuthally towards dawn when IMF reverses from westward (IMFy<0) to eastward (IMFy>0), and when Mercury approaches its perihelion. The IMFx dependence is consistent with existing observations and simulations which are ascribed to the asymmetry of dayside magnetospheric configuration between sunward and anti-sunward IMF conditions. We explain the IMFy and IMFz dependences in terms of component reconnection of the magnetospheric field merging with By-dominant and Bz-dominant IMF, respectively. The control of the Mercury solar orbit phase on the intensity and local time location of the disturbance peak are possibly arising from the modulations of the heliocentric distance on the solar wind ram pressure.
The existence of significant IMF dependence suggests the IMF orientation plays a role in the convection configuration at Mercury. The IMFy-dependence at Mercury is opposite to that at Earth, suggesting that component reconnection at the dayside magnetopause is more important in the Hermean system than in the terrestrial one. This also implies that reconnection occurs at lower magnetic shear angles at Mercury which is one reason for its dynamic magnetosphere.