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Three-dimensional kinetic simulations of magnetotail dynamics

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The Earth's magnetosphere is a dynamic environment that features a complex interplay between fundamental plasma processes. The accessibility of the magnetosphere for detailed satellite measurements makes it an ideal natural laboratory for studying nonlinear magnetized plasma dynamics. Disturbances at the bow shock from the impinging solar wind can propagate downstream and drive instabilities in the extended magnetotail - potentially resulting in the onset of magnetospheric substorms. After decades of research, the physical mechanism underlying substorm onset remains one of the of the most important unresolved issues in magnetospheric physics. We present simulations of the magnetotail that capture both the near-earth dipole and the extended tail regions. We study the impact of solar wind driving on this configuration using 2D and 3D kinetic particle-in-cell simulations and compare with results from fluid simulations. The interplay between reconnection and cross-tail ballooning modes is investigated to determine their roles in the onset of magnetospheric substorms. The implications of these simulations for elucidating substorm onset is discussed by direct comparison with satellite measurements.

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