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Simulating Magnetotail Reconnection in the Presence of a Significant Guide Field

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For a large number of solar wind driven substorms a significant guide field is present in the magnetotail. We have developed a new simulation approach for magnetotail reconnection in which we combine results from global magnetohydrodynamic simulations of the solar wind, magnetosphere and ionosphere system with large-scale 3D particle-in-cell simulations of the magnetotail. In this approach we first run a global MHD simulation driven by upstream solar wind observations. Then we use the results from the MHD simulation to set the initial and boundary conditions of a large-scale PIC simulation. We have selected the iPIC3D kinetic code to go along with the UCLA global simulation model. Our approach allows us to investigate indicators of reconnection in a realistic magnetospheric configuration, which is essential to determine the dynamics of the substorm process, in particular the evolution of reconnection and dipolarization fronts.

In preparation for the MMS phase in the magnetotail, we have developed an analysis system with multiprobes so we can directly compare the simulation results with MMS observations and have applied our multiscale simulation approach to the solar wind driven substorm observed on March 1, 2008. This substorm was characterized by a significant guide field. In the PIC simulation fast but episodic reconnection is found in the near-Earth tail. The reconnection has a complex 3D structure. When normalized by the Alfvén speed and magnetic field magnitude, the reconnection rate although highly variable oscillates about the expected value of 0.1. The location of reconnection also is highly variable. In the simulation it moves several RE across the tail in less than two minutes. We have evaluated several indicators of reconnection and find that agyrotropy (or non-gyrotropy) is the most reliable indicator.