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The Three Dimensional Structure and Dynamics of Magnetotail Reconnection

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Magnetic reconnection is a fundamental process by which magnetic energy is dissipated and converted into particle energy. In the next few months the Magnetosphere Multi-Scale Mission (MMS) will provide high resolution observations of reconnection and its consequences in the magnetotail. Of high priority will be observations of the electron diffusion region (EDR) where the actual process of reconnection is thought to occur. In preparation for the MMS observations we have investigated tail reconnection in a realistic magnetospheric configuration by using a new approach that combines a global magnetohydrodynamic simulation of the solar wind, magnetosphere and ionosphere system with a large scale (30X12X12RE) implicit particle-in-cell (iPic3D) simulation (see Lapenta et al., 2016 Geophys. Res. Lett. 43, 515-524, doi:10.1002/2015GL066689 for a discussion of the technique). In particular we have investigated the three dimensional structure and dynamics of tail reconnection during a substorm on February 15, 2008. We found that just earthward of the reconnection site the tail becomes highly structured in the Y direction in the GSM coordinate system. The structures result from an instability associated with strong shear flows in the Y direction within the current sheet. In particular we found that the work done by the magnetic field J•E in the electron frame alternated between positive and negative although the net J•E was positive. We used several methods for identifying the EDR (non-gyrotropy, slippage, the non-ideal terms in OHM's law as well as J•E) and found that all gave false positive results in some regions of the tail. However all of the approaches gave positive results in some of the small structures with J•E positive. These putative EDRs extended ($\sim$2di, >1di, $\sim$1di) in the X, Y and Z directions.