Kinetic Simulations of Thinnest Current Sheets as detected by Cluster.

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Recently reported observations from Cluster in the magneto-tail show existence of extremely thin current sheets (ETCSs). They have thickness of just a few electron skin depth (L_e), in contrast to the previously reported thin current sheets (TCSs) having thickness of ion skin depth (L_i). This suggests that the reconnecting current sheets evolve over scale size ranging from much larger than L_i to ones to the limiting smallest width $\sim L_e$. The phase of the current sheet (CS) evolution when the magnetic reconnection occurs in such a CS has remained a nagging challenge. We report here three-dimensional kinetic simulations of ETCSs using a particle-in-cell code with electron to ion mass ratio M/m=1836. Our simulation results show the following important features of an evolving CS: (i) Thinning process of a non-equilibrium CS when started with a CS of scale size several L_e, (ii) The thinning occurs via counter propagating magneto-sonic waves, (iii) Setting of convergent electric fields pointing toward the CS center during the course of the thinning, (iv) Direct acceleration of unmagnetized ions by the electric fields toward the CS center setting counter-streaming in ion flow, (v) E×B drift of the electrons, which completely support the current in the CS, (vi) Current-sheet-driven electrostatic instabilities (CSDEI) mostly confined within the CS, (vii) Electron drift and developing shear in the drift provide free energy for the CSDEI, (viii) Electron heating transverse to the anti-parallel magnetic field generating temperature anisotropy, (ix) Generation of large anomalous resistivity and (x) Current disruption (CD) in the center of the CS where CSDEI amplitude maximizes. The current disruption triggers the onset of electron tearing and magnetic reconnection. We will present such results from our simulations with magnetic field configurations consisting of (i) purely anti-parallel B_x, (ii) anti-parallel B_x plus a guide field B_y and (iii) anti-parallel B_x plus a guide field B_y and a so-called north-south weak component B_z. We also present a quantitative comparison with Cluster data.