

PIC simulations of electron acceleration by magnetic reconnection with multiple magnetic islands

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Magnetic reconnection is a process that can produce energetic particles when magnetic energy is released. There are various locations in reconnection where particles can be accelerated and heated, such as X-lines, downstream regions, and magnetic islands. Recent Cluster satellite observations in the Earth's magnetotail [1] demonstrated that energetic electrons are found in magnetic islands, where enhancements of core magnetic fields and particle densities were also observed. Motivated by that study, we carried out 2D PIC simulations of a current sheet with multiple magnetic islands in hydrogen plasmas. In simulations with parameters of the Earth's magnetotail, we have shown that the most energetic electrons are generated in magnetic islands. We have found three sources for electron acceleration and heating; they are the out-of-plane electric field around X-lines, the in-plane electric fields in magnetic islands (electrons are energized because of wave-particle interaction by those fields), and magnetic island coalescence. There are qualitative agreements between the simulation data (enhancements of the number of energetic electrons, the particle density, and the core magnetic field) and the Cluster observations. We have also carried out simulations of reconnection in electron-positron plasmas in a relativistic Harris sheet. In those simulations, nonthermal energetic particles are found at X-lines, but a significant number of particles are energized in magnetic islands. The source of the energization is the out-of-plane electric fields in the two ends of the islands. Particles are reflected several times in the both ends of contracting islands and gain energy from those electric fields. Some of the islands are coalesced into larger islands, and both cooling and heating have been observed during the coalescence process. We will compare the acceleration and heating in both (hydrogen and electron-positron) plasmas.

[1] L.-J. Chen et al.: *Nature Physics* **4** (2008) 19-23.