DPP12-2012-001570

Abstract for an Invited Paper
for the DPP12 Meeting of
the American Physical Society

Large-Scale Electron Acceleration by Parallel Electric Fields During Magnetic Reconnection[1]

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During reconnection in magnetized plasma stress in the magnetic field is reduced through changes in the field line topology. The process is often accompanied by an explosive release of magnetic energy and is implicated in a range of astrophysical phenomena. In the Earth's magnetotail, reconnection energizes electrons up to hundreds of keV and solar flare events can channel up to 50% of the magnetic energy into the electrons resulting in superthermal populations in the MeV range. Electron energization is also fundamentally important to astrophysical applications yielding a window into the extreme environments. The conventional wisdom has been that magnetic-field-aligned electric field ($E_{||}$) during reconnection are confined to small regions around the diffusion region and along separatrices, and it has been argued that direct acceleration is too small to explain observations. In contrast, here we show that during reconnection powerful energization of electrons by $E_{||}$ can occur over spatial scales which hugely exceed previous theories and simulations. In our kinetic simulation $E_{||}$ is supported by non-thermal and strongly anisotropic features in the electron distributions not permitted in standard fluid formulations, but routinely observed by spacecraft in the Earth's magnetosphere. This allows for electron energization in spatial regions that exceed the regular d_e scale electron diffusion region by at least three orders of magnitude [1].

[1] J Egedal, et al., Nature Physics 8, 321-324, 2012.

[1]This work was supported by NASA Grant NNX10AL11G.