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Multi-satellite observations of the electron diffusion region, neighboring islands, and electron acceleration[1]

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Based on data from the four-satellite mission Cluster and particle-in-cell simulations, we provide new insight into collisionless reconnection and particle energization. A spatially extended electron current sheet (ecs), its neighboring magnetic islands, and bursts of energetic electrons are identified during a magnetotail reconnection event with no appreciable guide field. One spacecraft crossed the ecs earthward of the reconnection null, and together with the other three spacecraft, registered the following properties: One, the ecs is co-located with a layer of electric fields normal to the ecs, and pointing toward the ecs. Two, within the ion diffusion region, the electron density varies by a factor of 3-4 along the ecs normal direction with a local maximum at the ecs center, and by about an order of magnitude along the exhaust direction. Three, in the inflow region up to the ecs and separatrices, electrons have a temperature anisotropy ($T_{e\|}/T_{e\perp} > 1$) and the anisotropy increases toward the ecs. Four, multiple d_i-scale magnetic islands are attached to the two ends of the ecs, and within each island, there is a burst of suprathermal electrons (Nature Physics, 4, 19-23, 2008). To compare with observations, we have developed detailed maps of electron distribution functions and DC electric fields within the diffusion region using 2D PIC simulations. We find that the electric field normal to the ecs is originated from charge imbalance and is of the ecs scale, and that ions also exhibit ecs-scale structures in response to this electric field. The above results indicate that ions and electrons are electrostatically coupled at the ecs, electrons are highly compressible, and electron acceleration during reconnection is linked to the dynamics of magnetic islands.

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