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Anisotropic Electron Tail Generation during Tearing Mode Magnetic Reconnection[1]

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Magnetic reconnection (MR) plays an important role in particle transport, energization, and acceleration in space, astrophysical, and laboratory plasmas. In the MST RFP, discrete MR events release large amounts of energy from the equilibrium magnetic field, a large fraction of which is transferred to the ions in a non-collisional process. Key features are anisotropic heating, mass and charge dependence, and energetic ion tail formation. Unlike the ions, the thermal electron temperature decreases at MR events, which is consistent with enhanced electron heat transport due to increased magnetic stochasticity. However, new high-speed x-ray spectrum measurements reveal transient formation of a non-Maxwellian energetic electron tail during MR. The energetic tail is characterized by a power-law, $E^{-\gamma}$, with the spectral index (γ) decreasing from 4.2 to 2.2 at MR, and then increasing rapidly to 6.8 due to increased stochastic transport. The x-ray emission peaks in a radial view and is symmetric in the toroidal direction, indicating an anisotropic electron tail is generated. The toroidal symmetry of the electron tail implies runaway acceleration is not a dominant process, consistent with the net emf, ηJ_{ll}, being smaller than the Dreicer field. Modeling of bremsstrahlung emission shows that a power-law electron tail distribution that is localized near the magnetic axis will yield strong perpendicular anisotropy, consistent with x-ray measurements in the radial and toroidal views. A strong correlation between high energy x-ray flux and tearing mode dynamics suggests a turbulent mechanism is active. This implies that the electron tail formation most likely results from a turbulent wave-particle interaction.

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