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Ion energization during magnetic reconnection in the RFP laboratory plasma[1]

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Particle energization via the conversion of magnetic energy to kinetic energy is a widely occurring phenomena in space, astrophysical, and laboratory plasmas. In the MST Reversed-Field Pinch, a device that magnetically confines a high-temperature plasma, ions are strongly heated during impulsive magnetic reconnection events. Three new experimental observations may help distinguish among theoretical explanations. First, spatially localized spectroscopic measurements of impurity C^{+6} ions reveal that the thermal heating is anisotropic, with the perpendicular temperature always increasing more than the parallel temperature. Second, measurements of neutral particle energy spectra and neutron flux show the generation of a high-energy tail on the distribution function of the majority ions during reconnection events. The high-energy ion density is typically a few percent of thermal ion density, and the high-energy ions have a power-law energy spectrum. Possibly related is the recent observation of acceleration of neutral-beam-injected fast ions to energies above their injection energy (25 keV) during reconnection events. The ion acceleration mechanism may be distinct from the thermal heating mechanism, although both phenomena exhibit characteristics that are clearly dependent on plasma density. Third, spectroscopic measurements of various impurity ions (C, N, O, and Al) made in the MST edge plasma suggest that the change in impurity ion temperature during a reconnection event may have a charge/mass dependence. There are several possible theoretical ion energization mechanisms; these new observations will be compared to predictions from these theories.

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