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Ion Heating During Reconnection in the Madison Symmetric Torus

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New spatially and temporally resolved measurements of ion temperature in MST provide new insight into the long observed ion heating associated with reconnection, and strong constraints on possible theories for the heating. Ion heating in MST is a strong effect, with a transient heating power of up to 50 MW during large reconnection events, resulting in ion temperatures > 2 keV in high current plasmas. Recently, such ion heating has been used to good effect: to produce high ion temperatures that are then sustained during plasma periods with improved confinement. The heating power during a reconnection event derives from a drop in global stored magnetic energy. Two diagnostic neutral beams are used to make fast localized measurements of impurity ions (via fast charge exchange recombination spectroscopy) and majority ions (via Rutherford scattering). Spatial profiles of the heating show a link between where reconnection occurs and where heating occurs. During large reconnection events involving many coupled reconnection sites, a broadly distributed heating profile is observed. Conversely, heating is localized to the edge in smaller reconnection events involving only edge resonant modes. Impurities are heated more strongly than bulk deuterium ions in deuterium plasmas (by about a factor of 2). This suggests a dependence on mass or charge. Many potential ion heating theories have been advanced but all fail to capture all of the observed features. Recent calculations evaluate viscous and cyclotron damping. Viscous damping of tearing mode flows could be important if strong, localized flow gradients are present, encouraging a search for such flows. A cascade of fluctuation power to ion gyroradius scales appears too weak for direct bulk heating, but could be important for impurity heating. Magnetic pumping can be important during plasma startup but should be less so during the discharge flattop where strong heating is still observed. Work supported by U.S.D.O.E. and N.S.F.