Continuous, Localized Ion Heating due to Magnetic Reconnection in a Low Aspect Ratio Tokamak

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Plasmas in the Pegasus ST are initiated and grown by local helicity injection (LHI) current drive, resulting in I_p > 180 kA with I_{inj} = 5 kA. The LHI system consists of 3 adjacent electron current sources that inject helical current streams into the plasma edge and generate toroidal current through magnetic reconnection. Two sources of reconnection activity exist: a periodic reconnection of two adjacent toroidal transits of the current streams; and a continuous reconnection of current streams from adjacent injectors. NIMROD simulations show that the first process gives rise to LHI current drive through the formation of free standing axisymmetric current rings. This process results in large amplitude, low frequency (~40kHz) n=1 magnetic oscillations. Reconnection also occurs more continuously between co-injected current streams, and is reflected by the presence of high frequency (>50 kHz) magnetic activity. Anomalously high ion temperatures are driven by this reconnection activity, with T_i~800 eV during LHI in contrast to T_i ~60 eV from ohmic heating alone. Surprisingly, the anomalously high T_i are temporally correlated with the amplitude of high frequency activity and not the dominant n=1 mode. Spatial profiles of T_i show a 800 eV edge temperature falling to ~150 eV near the plasma core, consistent with edge localized reconnection heating. The He-II $T_{i,\perp}$ was found to scale linearly with v_A^2 and guide field, while $T_{i,\parallel}$ saw little change, as predicted by two-fluid reconnection theory. In contrast, initial measurements of the charge and mass dependence of T_i suggests the heating is not consistent with direct ion cyclotron resonance heating. In addition to testing reconnection theory, this edge ion heating could significantly impact the LHI power balance, and may offer a path to increase β in high performance plasmas.

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