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Characterization of beam-driven instabilities and current redistribution in MST plasmas[1]

E. PARKE, UCLA

A unique, high-rep-rate (>10 kHz) Thomson scattering diagnostic and a high-bandwidth FIR interferometer-polarimeter on MST have enabled characterization of beam-driven instabilities and magnetic equilibrium changes observed during high power (1 MW) neutral beam injection (NBI). While NBI leads to negligible net current drive, an increase in on-axis current density observed through Faraday rotation is offset by a reduction in mid-radius current. Identification of the phase flip in temperature fluctuations associated with tearing modes provides a sensitive measure of rational surface locations. This technique strongly constrains the safety factor for equilibrium reconstruction and provides a powerful new tool for measuring the equilibrium magnetic field. For example, the n = 6 temperature structure is observed to shift inward 1.1 ± 0.6 cm, with an estimated reduction of q_0 by 5%. This is consistent with a mid-radius reduction in current, and together the Faraday rotation and Thomson scattering measurements corroborate an inductive redistribution of current that compares well with TRANSP/MSTFit predictions. Interpreting tearing mode temperature structures in the RFP remains challenging; the effects of multiple, closely-spaced tearing modes on the mode phase measurement require further verification. In addition to equilibrium changes, previous work has shown that the large fast ion population drives instabilities at higher frequencies near the Alfvén continuum. Recent observations reveal a new instability at much lower frequency (∼7 kHz) with strongly chirping behavior. It participates in extensive avalanches of the higher frequency energetic particle and Alfvénic modes to drive enhanced fast ion transport. Internal structures measured from T_e and n_e fluctuations, their dependence on the safety factor, as well as frequency scaling motivate speculation about mode identity.

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