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Fast Ion Confinement and Stability of an NBI-heated RFP[1]

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Energetic ions are fundamentally important for both fusion and astrophysical plasmas. While well-studied in tokamak and stellarator plasmas, relatively little is known in RFP plasmas about the dynamics of fast ions and the effects they cause as a large population. These studies are now underway in MST with an intense 25 keV, 1 MW hydrogen neutral beam injector (300 MW/m^2 at injection port). Measurements of the time-resolved fast ion distribution via a high energy neutral particle analyzer, as well as beam-target neutron flux (when NBI fuel is doped with 3-5% D_2) both demonstrate that the fast ion population is consistent with classical slowing of the fast ions, zero cross-field transport, and charge exchange as the dominant ion loss mechanism. A significant population of fast ions develops during the 20 ms (several times the bulk plasma confinement time) NB injection. TRANSP simulations predict a super-Alfvenic ion density of up to 15% of the electron density with both a significant velocity space gradient and a sharp radial density gradient. There are several effects on the background plasma including enhanced toroidal rotation, electron heating and an altered current density profile. The abundant fast particles affect the plasma stability. Fast ions at the island of the core-most resonant tearing mode have a stabilizing effect, and up to 50% reduction in the magnetic fluctuation amplitude is observed during NBI. Simultaneously, beam driven instabilities are observed for the first time in the RFP. Repetitive $\sim 50\mu s$ bursts of m=1 modes have scaling signatures of both Alfvenic and continuum energetic particle modes. The dominant modes are n=4 (EP-like) and n=5 (AE-like), which nonlinearly couple to an n=1 mode. Modeling for TAE modes in the RFP is performed using AE3D, but the mode features are not fully consistent with the code predictions.

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