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Fast Ion Losses and Plasma Response Induced by externally Applied Magnetic Perturbations on DIII-D

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Externally applied resonant magnetic perturbations (RMPs), which are useful for suppressing Edge Localized Modes, modify the axisymmetric equilibrium fields on DIII-D, altering the confinement of fast ions and leading to increased prompt losses from beam ions born inside the last closed flux surface (LCFS). The light ion beam probe (LIBP) technique [1] uses beam ions to probe internal magnetic perturbations and infer the displacement of fast ion orbits traversing through them using signals from a scintillator-based fast ion loss detector (FILD). A rigidly rotating n=1 RMP was applied to several DIII-D discharges in both L-mode and H-mode with a magnetic spectrum created by displacing the phase of the upper and lower internal coils by $\Delta\phi_{UL} = 240°$. The internal coils on DIII-D consist of two sets of 6 window frame coils in the outer wall: One above the midplane, and one above. The total n=1 perturbation includes both the vacuum fields generated by the internal coils and the fields internally generated by the plasma response. Magnetic coils located at the midplane on the low-field-side measured lower plasma responses after transitioning from L-mode into H-mode: a decrease of 34% for the B_r measurements and 50% for the B_p measurements; however, analysis of losses from a co-injected tangential neutral beam show that losses induced by the RMPs account for a larger fraction of prompt losses in H-mode. The ratio of losses fluctuating at the RMP rotation frequency to constant prompt losses, $\Delta F/\bar{F}$, increased by 62% after the transition into H-mode.
Simulations of the plasma response using M3D-C1 show a decrease in average amplitude of the response in H-mode near the outer midplane, consistent with experimental findings. Using these fields to follow particles in the code ASCOT5 shows that the RMP induced losses are concentrated mostly at the outer midplane and vessel floor, with FILD-impacting ions being born inside the LCFS.
[1] X.Chen et al, Rev Sci Instrum 85, 11E701 (2014)
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