Contribution ID: **246** Type: **Poster**

EX/P4-27: Probing Resistive Wall Mode Stability Using Off-axis NBI

Wednesday, 10 October 2012 14:00 (4h 45m)

DIII-D experiments with off-axis neutral beam injection (NBI) yield evidence of modifications to resistive wall mode (RWM) stability. Measurements of the plasma response to slowly rotating, applied n=1 perturbations decrease in amplitude as the fractional mix of off-axis NBI power is increased at constant normalized beta. This reduction of the plasma response amplitude due to the off-axis injection is observed in repeatable plasmas over a range of plasma rotation values, and is correlated with increased pitch-alignment of the fast ion slowing-down distribution. Present day tokamaks are routinely able to operate above the ideal MHD no-wall beta-limit predicted for n=1 external kink instabilities, and a theory incorporating kinetic modifications to the ideal MHD RWM dispersion relation is consistent with the parametric dependencies of experimental stability measurements. The present theory features several mechanisms that lead to an exchange of energy between the RWM and kinetic particle populations, including resonances between trapped thermal ions and the bulk plasma rotation, a generic stabilizing influence of trapped energetic ions independent of plasma rotation, and damping due to passing ions near rational flux surfaces. Recent experiments exploited the new off-axis NBI capability on DIII-D to investigate the impact of changing the fractional off-axis NBI power and torque on RWM stability at constant normalized beta and plasma internal inductance. Transport simulations based on reconstructions of the experimental equilibria indicate increased pitch-alignment of the fast ion slowing-down distribution and a decreased trapped fraction as the off-axis NBI power is increased. The observed increase in RWM damping due to off-axis NBI provides a new test for passive stability models needed to predict performance limits in ITER and future burning plasma devices.

This work was supported in part by the US Department of Energy under DE-FG02-04ER54761, DE-AC52-07NA27344, DE-FG02-08ER85195, DE-FC02-04ER54698, and DE-AC02-09CH11466.

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Session Classification: Poster: P4

Track Classification: EXS - Magnetic Confinement Experiments: Stability