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EX/P8-08: Stabilization of Disruptive Locked Modes by Magnetic Perturbations and Electron Cyclotron Current Drive at DIII-D

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Magnetic perturbations were used to control the rotation and toroidal phase of locked modes (LMs) and of their rotating precursors, when present, thus enabling the first full suppression of locked modes (LMs) by modulated or continuous Electron Cyclotron Current Drive (ECCD). In a first set of experiments the applied perturbations were static and caused the rotating precursor to directly lock in a position such that its O-point was accessible to localized, continuous ECCD. ECCD in the O-point rapidly and completely stabilized the LM and avoided a disruption. Higher ECCD power was more stabilizing, as expected, and ECCD was more efficient than simple EC heating in the O-point, also as expected. For ECCD in the X-point the LM was increased in amplitude. For ECCD at intermediate toroidal locations it grew slower and the disruption was delayed, but not avoided. LM suppression permitted disruption-free operation at beta_N as high as 2.5 in discharges which otherwise disrupted at beta_N as low as 1.7. The confinement was also improved and the H-mode never lost, as a result of LM suppression. Complete LM stabilization was observed in slowly rotating plasmas, for balanced Neutral Beam Injection (NBI). For unbalanced NBI, instead, the LM was often unlocked and accelerated by the NBI torque before being completely suppressed by the ECCD. In other experiments, rapidly rotating magnetic perturbations were used to unlock the island or catch it when still rotating, and sustain its rotation at up to 100 Hz. At the same time the ECCD was modulated synchronously with the driven rotation of the island. The island amplitude was reduced when ECCD was selectively applied in the island O-point, while current drive at the X-point increased the island size. Detailed data on ECCD in intermediate toroidal positions were collected by adopting slightly different frequencies for the ECCD modulation and island rotation, which was equivalent to slowly scanning the relative toroidal phase. The mode amplitude was observed to decrease as the rotation rate increased. This work was supported by the US Department of Energy under DE-FG03-97ER544156, DE-SC0006415, DE-FC02-04ER54698, and DE-AC52-07NA27344

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