Prospects for stabilization of neoclassical tearing modes by electron cyclotron current drive in ITER

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Abstract. The system planned for electron cyclotron current drive (ECCD) in ITER can mitigate the deleterious effects of neoclassical tearing modes (NTMs) provided that either adequate alignment of the ECCD to the rational surface is maintained or too large a misalignment is corrected on a time scale shorter than the deleterious plasma response to "large" islands. Resistive neoclassical tearing modes will be the principal limit on stability and performance in the ITER standard scenario as the drag from rotating island induced eddy current in the resistive wall (particularly from the $m/n = 2/1$ mode) can slow the plasma rotation, produce locking to the wall, and cause loss of high-confinement H-mode and disruption. Continuous wave (cw) ECCD at the island rational surface is successful in stabilization and/or prevention of NTMs in ASDEX Upgrade, DIII-D and JT-60U. Modulating the ECCD so that it is absorbed only on the rotating island O-point is proving successful in recovering effectiveness in ASDEX Upgrade when the ECCD is configured for wider deposition as expected in ITER. The models for the effect of misalignment on ECCD effectiveness are applied to ITER. Tolerances for misalignment are presented to establish criteria for both the alignment (by moving mirrors in ITER) in the presence of an island, and for the accuracy of real-time ITER MHD equilibrium reconstruction in the absence of an island, i.e. alignment to the mode or to the rational surface in the absence of the mode. The narrower ECCD with front steering makes precise alignment more necessary for the most effective stabilization even though the ECCD is still relatively broad, with current density deposition (full width half maximum) almost twice the marginal island width. This places strict requirements on ECCD alignment with the expected ECCD effectiveness dropping to zero for misalignments as small as 1.7 cm. The system response time for growing islands and slowing rotation without and with ECCD (at different misalignment) are provided for the plasma system controller to be developed. An alignment resolution error of no more than 1 cm and realignment rate of at least 1 cm/s are required for a moderate cw ECCD power so as to avoid locking. Finally, a case study in ITER of prompt dynamic alignment and suppression is presented.