DPP19-2019-000156

Abstract for an Invited Paper
for the DPP19 Meeting of
the American Physical Society

Controlled Healing of NTMs by Fueling Pellets in DIII-D and KSTAR and Impact on ECCD Requirements for Complete NTM Stabilization[1]

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DIII-D and KSTAR experiments with high field side deuterium pellet injection show a stabilizing effect of deep fueling on core 2/1 Neoclassical Tearing Mode (NTM) magnetic islands. NTM control is important as 2/1 islands can significantly degrade confinement and lead to plasma termination. DIII-D data and GENE non-linear gyrokinetic turbulence simulations with magnetic islands, presented here, qualitatively support the hypothesis that pellet triggered multi-scale NTM-turbulence interaction can cause islands to shrink. Deep fueling increases local gradients in the island region and concomitant local low-k turbulence in the expected range of the Micro Tearing Mode and Trapped Electron Mode instabilities. This can enhance transport through the island separatrices, reducing the pressure flat spot at the O-point and diminishing the NTM drive. Gyrokinetic simulations with the GENE code qualitatively support causality between increased gradients outside of the island, increased turbulence penetration into the island and reduced NTM drive. In sync with increased local gradients at q=2, a Mirnov probe array detects the reduction of the 2/1 magnetic amplitude. This interaction can reduce the required EC current for NTM suppression by 70%, as predicted by the Rutherford equation. These benefits can (i) extend NTM control solutions to operational regimes where the current drive efficiency is low - in particular ITER's planned operation at half magnetic field, where the 2nd harmonic absorption at q=2 will have lower current drive efficiency due to 3rd harmonic absorption in the edge, (ii) free up gyrotrons for use elsewhere and (iii) improve the net electricity output of future reactors. Thus NTM healing by pellets may offer substantial benefits for ITER.

[1]This material is based upon work supported by the Department of Energy under Award Number(s) DE-FC02-04ER54698.