Locked Neoclassical Tearing Mode Control by Means of Applied Magnetic Perturbations and Electron Cyclotron Current Drive*

F. Volpe,[1] R.J. La Haye,[2] R. Prater,[2] and E.J. Strait[2]

[1]*Max-Planck-Gesellschaft, Germany*
[2]*General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA*

Control of rotating neoclassical tearing modes (NTMs) by localized electron cyclotron current drive (ECCD) has proved successful on various tokamaks. However, in their interaction with the wall and with the machine error field, rotating NTMs can also "lock" or form directly as locked modes, without rotating precursors. Locked modes are less shielded by plasma rotation, tend to grow bigger, affect the confinement, particularly by causing the loss of H-mode, and can lead to disruptions.

Because they can lock with a toroidal phase such that they cannot necessarily be accessed by ECCD, a stabilization method more general than ECCD alone is required. This is especially true for ITER, where NTMs are predicted to rotate more slowly and be more prone to locking. ITER-like high β, low rotation conditions are reproduced in the DIII-D tokamak by balanced neutral beam injection,

A new technique was demonstrated on DIII-D, where a set of 12 internal coils, the I-coils, was used to exert static or rotating magnetic perturbations of toroidal mode number n=1 on an NTM of poloidal/toroidal mode number m/n=2/1, as soon as it locked. The perturbations were used to steer the mode and lock it with a new phase such that it could be stabilized by ECCD. Slowly rotating fields and a radial jog of the plasma were used to toroidally and radially align the island to the ECCD. The mode strength was measured by saddle loops; the effect of the perturbing coils on them was measured and subtracted. Mitigation of the locked NTM was obtained with this technique, with 1.3 MW of ECCD power; modeling suggests that 3 MW would completely suppress the island.

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