Locked Neoclassical Tearing Mode Control on DIII-D by ECCD and Magnetic Perturbations*

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*

email: volpe@fusion.gat.com, Phone: 858-455-2495, Fax: 858-455-4156

Neoclassical tearing modes (NTMs) in ITER are expected to initially rotate very slowly and thus be prone to stop rotating and "lock" to the resistive wall and error field. They can lock with a toroidal phase such that they cannot necessarily be accessed and suppressed by electron cyclotron current drive (ECCD), therefore a more general stabilization approach becomes necessary.

New techniques where ECCD is assisted by magnetic perturbations exerted by internal coils (I-coils) were tested at DIII-D. Balanced neutral beam injection allowed reproducing ITER-like conditions of high β (for mode onset) and low rotation.

In the first type of experiment, magnetic 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. 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.

In the second class of experiments, rotating fields unlocked the mode and sustained its rotation. This is useful in many ways: (1) it prevents further locking; (2) it rotationally mitigates the mode; (3) it brings the locked mode case into the well-studied, easy-to-stabilize rotating NTM case; and (4) it opens up the possibility to synchronize and phase-lock the mode rotation to the ECCD modulation, which is simpler than adapting the ECCD to the natural mode frequency and phase. Sustained rotation at up to ~60 Hz was demonstrated and a sudden mode mitigation was observed at ~10 Hz, which might be due to the island shrinking below a critical width, as a result of the rotationally improved shielding.

Finally, new detectors of rotating precursors of locked modes were developed. First results and plans for their application to pre-emptive locked mode control and avoidance will be presented.

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TOPICS: B. Application of EC waves to confinement and stability studies, including active control techniques for ITER