Advanced control of neoclassical tearing modes in DIII-D with real-time steering of electron cyclotron current drive

A S Welander[1], E Kolemen[2], R J La Haye[1], N W Eidietis[1], D A Humphreys[1], J. Lohr[1], S Noraky[1], B G Penaflor[1], R Prater[1], and F Turco[3]

[1]General Atomics, PO Box 85608, San Diego, California 92186-5608, USA
[2]Princeton Plasma Physics Laboratory, PO Box 451, Princeton, NJ 08543-0451, USA
[3]Columbia University, 116th St and Broadway, New York, New York 10027, USA
e-mail: welander@fusion.gat.com

Abstract. The system for control of neoclassical tearing modes (NTMs) in DIII-D now catches the NTM the moment it becomes unstable by turning on stabilizing electron cyclotron current drive (ECCD) and promptly bringing it back to stable before it has grown to large size. Between NTMs the ECCD can be turned off to save power which will improve the fusion gain, Q when used in ITER. This technique, named "Catch & Subdue" has been made possible by several advancements over the years at DIII-D. Firstly, ECCD must be very accurately aligned to the NTM and this is achieved by algorithms that probe how the NTM responds to changes in the alignment. Secondly the alignment must be maintained even when the NTM is gone so that the ECCD will immediately stabilize when turned on in response to a new NTM. This is made possible by real-time equilibrium reconstructions that include measurements of the motional Stark effect and by a refraction estimator. Thirdly, real-time steerable mirrors are now fast and accurate actuators for the alignment adjustments. Fouthly, early NTM detection is made possible by a real-time mode analysis that filters noise to minimize false positives. These various control elements will be described and followed by a discussion of further development needed for NTM control on ITER.

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