Abstract for an Invited Paper
for the DPP05 Meeting of
The American Physical Society

Active Control for Stabilization of Neoclassical Tearing Modes[1]

D.A. HUMPHREYS, General Atomics

We describe active control algorithms used by DIII-D to stabilize and maintain suppression of 3/2 or 2/1 neoclassical tearing modes (NTMs) using electron cyclotron current drive (ECCD) at the rational q-surface. The DIII-D NTM control system can determine the correct q-surface/ECCD alignment and stabilize existing modes within 100-200 ms of activation, or prevent mode growth with preemptive application of ECCD, in both cases enabling stable operation at normalized beta values above 3.5. Because NTMs can limit performance or cause plasma-terminating disruptions in tokamaks, their stabilization is essential to the high performance operation of ITER. The DIII-D NTM control system has demonstrated many elements of an eventual ITER solution, including general algorithms for robust detection of q-surface/ECCD alignment and for realtime maintenance of alignment following disappearance of the mode. This latter capability, unique to DIII-D, is based on realtime reconstruction of q-surface geometry by a Grad-Shafranov solver using external magnetics and internal motional Stark effect measurements. Alignment is achieved by varying either the plasma major radius (and the rational q-surface) or the toroidal field (and the deposition location). The requirement to achieve and maintain q-surface/ECCD alignment with an accuracy on the order of 1 cm is routinely met by the DIII-D Plasma Control System and these algorithms. We discuss the integrated plasma control design process used for developing these and other general control algorithms, which includes physics-based modeling and testing of the algorithm implementation against simulations of actuator and plasma responses. This systematic design/test method and modeling environment enabled successful mode suppression by the NTM control system upon first-time use in an experimental discharge.

[1]Supported by US DOE under DE-FC02-04ER54698.