DPP20-2020-000164

Abstract for an Invited Paper
for the DPP20 Meeting of
the American Physical Society

MHD Transient Seeding of Disruptive Neoclassical Tearing Modes[1]

JAMES CALLEN, University of Wisconsin - Madison

New toroidal theory coupled with analysis of DIII-D discharges have identified critical physics and parameters for which MHD transients (ELMs and sawteeth) seed growing neoclassical tearing modes (NTMs) that lead to locked modes and disruptions in tokamaks. It has been recognized since their experimental identification (Chang, Callen et al, PRL 1995) that NTMs require a transient excitation to seed robust algebraic temporal growth. A recent slab model (Beidler et al, PoP 2018) used NIMROD calculations to show externally imposed MHD transients in a flowing plasma in a sheared magnetic field can induce magnetic reconnection and growth of a nonlinear tearing mode at a resonant surface. A toroidal extension of this model explores how ELMs and sawteeth can seed growing m/n=2/1 NTMs in recent well-diagnosed ITER-baseline-scenario (IBS)-type DIII-D discharges. This new model involves: equilibrium and transient poloidal and toroidal plasma flows in a tokamak, magnetic reconnection induced by a MHD pulse, nonlinear modified Rutherford equation (MRE) for magnetic island growth (or decay), bootstrap current drive, NTM mode frequency dependence of the stabilizing ion polarization current, and mode frequency evolution in the toroidal geometry. Key conditions for robust NTM growth are benchmarked with data from multiple DIII-D discharges; they include a large enough bootstrap current drive and resonant delta B induced by the MHD transient to reduce the NTM mode frequency to open the usually stabilizing polarization current "gate." In ITER, order of magnitude smaller MHD transients are predicted to seed 2/1 NTMs. This work provides criteria for transient-MHD-induced excitation and robust growth of 2/1 NTMs, e.g., for real-time monitoring.

[1]Collaborators RJ La Haye, C Chrystal, CC Hegna, EC Howell, M Okabayashi, EJ Strait, RS Wilcox.Work funded in part by US DOE under DE-FG02-86ER53218, DE-FC02-04ER54698, DE-AC05-00OR22725, DE-AC02-09CH11466, DE-SC0018313.