Abstract for an Invited Paper
for the DPP02 Meeting of
The American Physical Society

A Mechanism for Tearing Mode Onset Near Ideal Stability Boundaries[1]

D.P. BRENNAN, Oak Ridge Institute for Science Education

The prevention of neoclassical tearing modes (NTMs) in tokamak plasmas is a major challenge for fusion. Ideal modes can seed NTMs through forced reconnection, yet in sawtoothing discharges it is not well understood why a particular sawtooth crash seeds an NTM after several preceding ones did not. Also, NTMs sometimes appear without an obvious ideal mode causing a seed island. Based on theoretical and experimental results a new mechanism for tearing mode onset is proposed and tested which explains these puzzling observations. Tearing stability calculations based on DIII-D experimental equilibria indicate tearing modes can be driven unstable by a rapid increase in the linear tearing stability index Delta just before onset. At the ideal limit Δ' becomes large and positive as it approaches a pole discontinuity. This increase in Deltacan initiate NTMs by two mechanisms. An increase in Delta decreases the neoclassical threshold, which can explain why a particular sawtooth crash seeds an NTM. A sufficient increase in Δ' can cause rapid growth of magnetic islands, which can explain the spontaneous growth of NTMs. Directly testable theoretical predictions are presented which are unique to this onset mechanism. The relative timescales of the change in Delta versus the effects of finite island width will determine the evolution of the island, and the eventual nonlinear state. These predictions are compared with results from new DIII-D experiments designed specifically to test this hypothesis. Integration of the modified Rutherford equation shows that these predictions are consistent with experimental observations. The NIMROD nonlinear 3-D resistive MHD code is used to evolve these equilibria to provide a comprehensive prediction of the island evolution during the early nonlinear phase.

[1]Work supported by U.S. DOE Contracts DE-AC05-76OR00033 and DE-AC03-99ER54463.