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Nonlinear tearing mode evolution in sawtoothing discharges*

D.P. Brennan,[1*] R.J. La Haye,[1] A.D. Turnbull,[1] L.L. Lao,[1] S.E. Kruger,[2] D.D. Schnack[2]

[1]General Atomics, P.O. Box 85608, San Diego, California 92186-5608.

[2]SAIC, San Diego, California

[*]Oak Ridge Institute for Science Education, Oak Ridge, Tennessee 37831.

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 in which NTMs are destabilized, this process is not well understood. A theoretical description is presented in which a particular sawtooth crash can seed an NTM, perhaps after several preceding sawteeth did not, due to any one of a number of reasons. Nonlinear mechanisms for tearing mode onset are studied based on ITER and DIII-D experimental equilibria using the NIMROD nonlinear 3-D resistive MHD code to evolve these equilibria in time and provide a comprehensive prediction of the island evolution during the early non-linear phase. The relative timescales of the change in linear instability drive versus the effects of finite island width and coupling drive will determine the evolution of the island, and the eventual nonlinear state. Time integration of the island evolution equation for an uncoupled mode is compared to these simulations and shows that both are consistent with the experimental observations in DIII-D. These results are then compared to the ITER case in light of scaling studies from the literature.

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