5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Interaction of Fast Ions with Neoclassical Tearing Modes in NSTX

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The impact of energetic particles on neoclassical tearing mode (NTM) stability is modeled and compared to experiments in the spherical tokamak NSTX. It is shown that energetic particles can be an important destabilizing mechanism for neoclassical tearing modes, in that they allow small magnetic islands to overcome the polarization current stabilization effect (Fig. 1), and the magnetic island growth may be damped with the loss of energetic particles due to orbit stochasticization (Fig. 2). These results are obtained using the energetic particle and magnetic island parameters determined self-consistently by TRANSP simulations augmented by the "kick model" for energetic particle transport by instabilities [1], which is validated recently in NSTX [2]. Inclusion of energetic particle effect improves the agreement between measured and predicted island width time evolution (Fig. 3) and may provide new insight on neoclassical tearing mode onset and growth. A new model is being implemented and tested in TRANSP for analysis and prediction of NTM stability in time-dependent simulations.

This manuscript is based upon work supported by the U.S. Department of Energy, Office of Science, and Office of Fusion Energy Sciences, and has been authored by Princeton University under Contract Number DEAC02-09CH11466 with the U.S. Department of Energy.

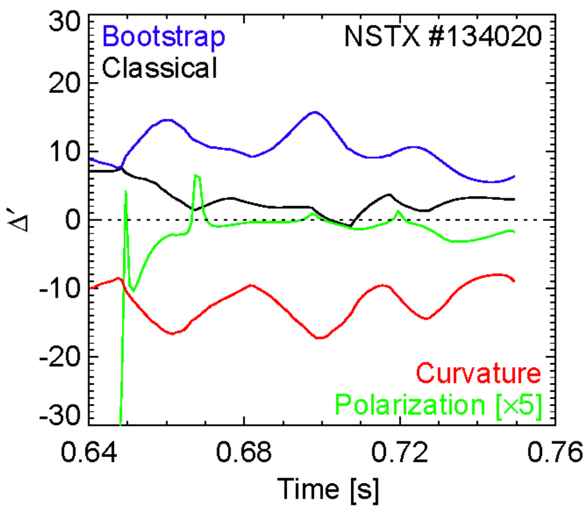

Fig. 1. Comparison of classical (black), bootstrap current (blue), polarization current (green) and curvature (red) effect on NTM stability. Without the energetic particle contribution, the polarization current effect should be suppressed to be zero for the simulation to match the measurement of island width.

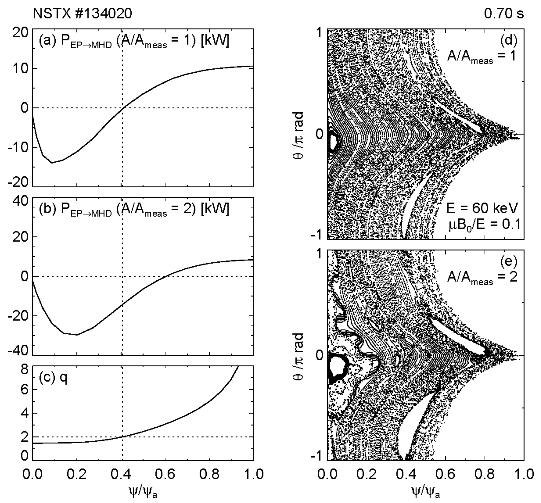

Fig. 2. Profiles of power transfer from energetic particle to modes for the case where mode amplitude is (a) the same, and (b) twice as measured mode amplitude, and (c) safety factor. Poincaré plots for the case where mode amplitude is (d) the same, and (e) twice as measured mode amplitude.

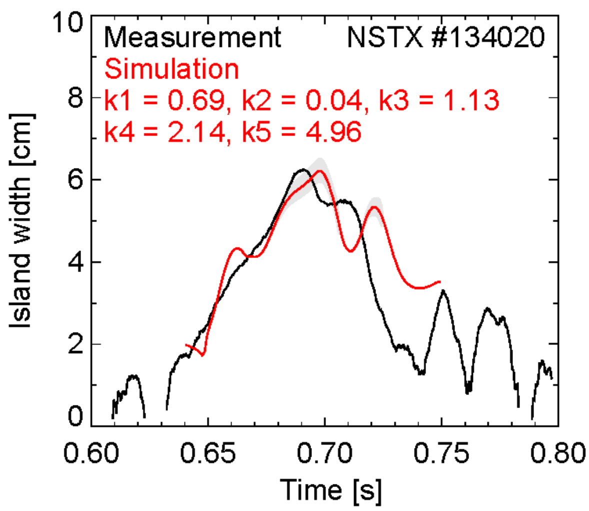

Fig. 3. Comparison of measured (black) and simulated (red) island width time evolution. The shaded area indicates the error bar of the simulation. Modified Rutherford equation coefficients $k_1 - k_5$ are also shown.

References
[1] Podestà *et al*., Plasma Phys. Control. Fusion **59** 095008 (2017).
[2] Yang *et al*., Plasma Phys. Control. Fusion **63** 045003 (2021).