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Sawtooth stabilization and destabilization by neutral beam generated fast ions in DIII-D negative and positive triangularity plasmas

D. Liu[1], Y. Q. Liu[1], W.W. Heidbrink[2], M. A. Van Zeeland[1], L. N. Zhou[3], M. E. Austin[4], and A. Marinoni[5]

[1] General Atomics, [2] University of California, Irvine, [3] Dalian Maritime University,
[4] University of Texas, Austin, [5] Massachusetts Institute of Technology
e-mail (speaker):liud@fusion.gat.com

Recent DIII-D experiments show, for the first time, that sawtooth stability is strongly affected by anisotropic fast ions from Neutral Beam Injection (NBI) in negative triangularity plasmas, similar to previous observations in conventional positive triangularity plasmas.[1] As shown in Fig. 1, fast ions from co-(counter-) current NBI are stabilizing (destabilizing) for sawteeth, resulting in longer (shorter) sawtooth periods. The relative change of sawtooth period and amplitude is more than a factor of two. Non-perturbative toroidal modeling, utilizing the MHD-kinetic hybrid stability code MARS-K.[2], reveals an asymmetric dependence of the stability of the n = 1 internal kink on the injection direction of NBI, being qualitatively consistent with the experimentally observed sawtooth behavior. The MARS-K modeling results suggest that anisotropic fast ions affect the mode growth rate and frequency through both adiabatic and non-adiabatic contributions. The asymmetry of the internal kink mode instability relative to the NBI direction is mainly due to the non-adiabatic contribution of passing fast ions, which stabilize (destabilize) the internal kink with the co-(counter-) current NBI as compared to the fluid counterpart. On the other hand, Finite Orbit Width (FOW) correction to passing particles partially cancels the asymmetry. Trapped particles are always stabilizing due to precessional drift resonances. Modeling also suggests that fast ions affect the internal kink in a similar manner between negative and positive triangularity plasmas, although being slightly more unstable in the negative triangularity plasmas already in the fluid limit. The similarity is mainly attributed to the fact that the mode is localized in the plasma core region, with very similar eigenmode structures in both negative and positive configurations. Furthermore, MARS-K modeling indicates that other factors, such as the plasma rotation and drift kinetic effects of thermal plasmas, weakly modify the mode stability as compared to the drift kinetic resonance effects and FOW correction of fast ions.

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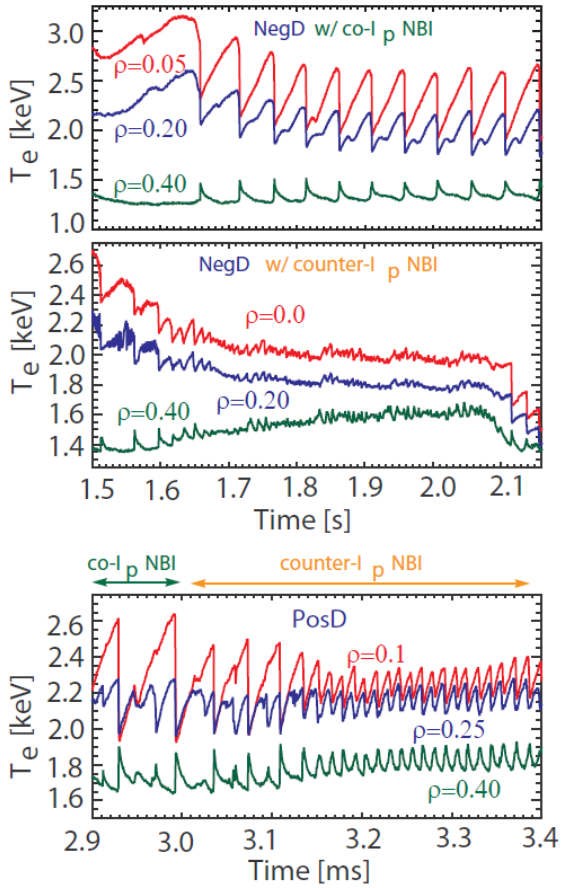

Figure 1 DIII-D experiments show that fast ions from co-(ctr-) I_p NBI strongly stabilize (destabilize) sawteeth in both negative and positive triangularity plasmas.

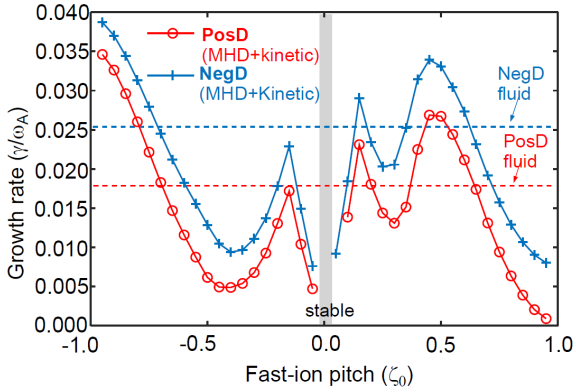

Figure 2 MHD-kinetic hybrid MSRS-K modeling shows an asymmetric dependence of the internal kink mode growth rate on the injection direction of neutral beam in both negative and negative triangularity, qualitatively consistent with the experimental sawtooth behavior.

References

[1] D. Liu *et al* Nucl. Fusion, 2022 (accepted)

[2] Y.Q. Liu Liu *et al*, Phys. Plasmas 15, 112503 (2008)