Hybrid simulation of fishbone instabilities in the EAST tokamak

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Hybrid simulations with the global kinetic-magnetohydrodynamic (MHD) code M3D-K[1, 2] have been carried out to investigate the linear stability and nonlinear dynamics of beam-driven fishbone in the Experimental Advanced Superconducting Tokamak (EAST) experiment[3]. Linear simulations show that a low frequency fishbone instability is excited at experimental value of beam ion pressure. The mode is mainly driven by low energy beam ions via precessional resonance. The results are consistent with the experimental measurement with respect to mode frequency and mode structure. When the beam ion pressure is increased to exceed a critical value, the low frequency mode transits to a second branch of fishbone with much higher frequency. This new mode is driven by higher energy beam ions. Nonlinear simulations show that the frequency of the low frequency fishbone chirps up and down with corresponding hole-clump structures in phase space, consistent with the Berk-Breizman theory. In addition to the low frequency mode, the high frequency fishbone is excited during the nonlinear evolution. For the transient case of beam pressure fraction where the low and high frequency fishbones are simultaneously excited in the linear phase, only one dominant mode appears in the nonlinear phase with frequency jumps up and down during nonlinear evolution.

References

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