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Hybrid Simulations of beam-driven fishbone and TAEs in NSTX

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Energetic particle modes and Alfvénic modes driven by super-Alfvénic beam ions were routinely observed in neutral beam heated plasmas on the National Spherical Torus Experiment (NSTX). These modes can significantly impact beam-ion transport, thus causing beam-ion redistribution and losses. In this paper we report on new self-consistent hybrid simulations of both fishbone instability and TAEs in NSTX plasmas using M3D-K code. First, linear simulations of beam-driven fishbone show that a new instability region appears for q_min > 1.35 when plasma toroidal rotation is included. The corresponding fishbone mode structure has strong ballooning feature. Both passing and trapped beam particles contribute to the instability drive. Nonlinear simulation shows strong mode frequency chirping as beam ion distribute is substantially redistributed in radial direction. It is found that trapped particles are mainly responsible for the nonlinear frequency chirping although passing particles'instability drive is comparable to that of trapped particles. Second, nonlinear simulations of multiple beam-driven TAEs and the n=1 fishbone have been carried out for the first time. The simulation results show strong interaction between multiple TAEs and fishbone that either enhances or reduces saturation level of individual modes due to overlap of wave particle resonances in phase space. Furthermore it is found that the mode saturation levels are very sensitive to q_min. When q_min drops below a critical value ˜1.19, the mode amplitudes increase sharply to large values. This result is similar to the observed transition to TAE avalanche as q_min decreases in NSTX.

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