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Hybrid simulation of fishbone instabilities with reversed safety factor profile

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Linear stability and nonlinear dynamics of the fishbone instabilities with reversed safety factor profile have been investigated by the global kinetic-magnetohydrodynamic (MHD) code M3D-K [1, 2]. For the consideration of the fishbone instability, there are two different types of the fishbone instability: dual resonant fishbone (DRF) with double q = 1 surfaces and non-resonant fishbone (NRF) with the minimum value of safety factor q_{min} a little larger than unity. Based on EAST-like parameters, linear simulations show that the DRF is excited by the trapped beam ions when the fast ion pressure increases to exceed a critical value, and the mode structure of DRF exhibits splitting feature due to double q = 1 surfaces. When q_{min} increases from below unity to above unity, the fishbone instability transits from the DRF to the NRF, and the mode frequency of the NRF is higher than the DRF as the NRF is resonant with fast ions with larger precessional frequency. Nonlinear simulations show that the saturation of the DRF is due to MHD nonlinearity with a large n = 0 component. However, the saturation of the NRF is mainly due to the nonlinearity of fast ions, and the frequency of the NRF chirps down nonlinearly. The fast ions are redistributed and become flattened due to the DRF or the NRF, and the transport level of the fast ions due to the NRF is weaker with more centrally radial redistribution region in comparison with the DRF.

References

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