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Hybrid simulations of of beta-induced Alfven eigenmode with reversed safety factor profile

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Based on the experimental parameters in HL-2A tokamak, the linear stability and nonlinear dynamics of BAE with reversed safety factor q profile are investigated by using kinetic-MHD code M3D-K. It is found that the $(m/n = 3/2)$ BAE is excited by co-passing energetic ions with $q_{min} = 1.5$ in linear simulation, and the mode frequency is consistent with experimental meuasurement. The simulation results show that the energetic ions β_h, the injection velocity v_0 and orbit width parameter ρ_h of energetic ions are important parameters determining the drive on BAE. The effect of ρ_h is determined by the orbital averaging, while the effect of v_0 is associated with the fraction of resonant ions. Furthermore, the effect of q_{min} (with fixed shape of q profile) is studied, and it is found that: when $q_{min} \leq 1.5$, the excited modes are BAEs, which are located near $q = 1.5$ rational surfaces; when $q_{min} > 1.5$, the excited modes are reversed-shear Alfven eigenmodes (RSAEs), which are localized around $q = q_{min}$ surfaces. Nonlinear simulation results show that the nonlinear dynamics of BAE depends on the EP drive. For strongly driven case, firstly, redistribution and transport of engetic ions are trigged by $3/2$ BAE, which raised the radial gradient of energetic ions distribution function near $q = 2$ rational surface, and then an EPM $(m/n = 4/2)$ is driven in nonlinear phase. Finally, these two instabilities triggered significant redistribution of energetic ions, which results in the repetitive and mostly-downward frequency chirping of $3/2$ BAE. For weakly driven case, there are no $4/2$ EPM being driven and repetitive chirping in nonlinear phase, since the radial gradient near $q = 2$ rational surface is small and almost unchanged.

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