Nonlinear interaction dynamics between double tearing mode and Kelvin-Helmholtz instability due to shear flows

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Double tearing mode (DTM), a very violent MHD instability, can be produced in the tokamak devices with revised magnetic shear (RMS) configuration[1]. The shear flows have been considered as one of plausible candidates to suppress the DTM. However, strong shear flows may also be unstable for the Kelvin-Helmholtz (KH) mode so that the DTM and the KH instablity may coexist and nonlinearly interact. In this work, based on reduced MHD model in slab geometry, we simulate the nonlinear evolution of DTM coexisting with KH fluctuations excited around rational surfaces to understand the mechanism of interaction between multi-modes.

Both initial value simulation and eigenvalue analysis show that weak shear flows stabilize the DTM with antisymmetric islands and destabilize that with symmetric islands but cannot significantly change the global reconnection which is linked to the generation of the zonal flows around the resistive layers[2]. For strong shear flows, the KH mode with higher mode number, characterized by electrostatic fluctuations, is robustly unstable. Simulations exhibit a complex interaction process between two instabilities with five phases: (1) linear growth of the high m KH instability; (2) KH saturation due to zonal flow generation; (3) linear growing phase of new instability with m=1; (4) nonlinear growing phase of the m=1 mode (corresponding to the Rutherford regime); finally (5) full magnetic reconnection phase. It is observed that the linearly stabilized DTM by the shear flows can be destabilized again and then globally reconnect. The nonlinear interaction dynamics at each phase will be discussed in detail.

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