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Studies of Impact of Edge Current Profiles, Plasma Shaping, Nonlinearity on Edge Localized Modes with BOUT++ Code

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This work extends previous BOUT++ work to systematically study the edge current driven kink mode, the effect of plasma shaping on the ELMs, to benchmark with other codes, and to validate the BOUT++ nonlinear ELM simulation on EAST tokamak experiments. A sequences of equilibrium with different edge current is generated with the CORSICA code, by keeping total current and pressure profile fixed. With the edge current increasing, the dominant modes are changed from high-n ballooning modes to low-n kink modes. We found the edge current provides stabilizing effects on high-n ballooning modes, but not always provides the destabilizing effect on edge kink mode. We benchmarked BOUT++ linear results with GATO and ELITE codes. It is showed that the vacuum model has important effect on the edge kink mode calculation. The resistivity vacuum has destabilizing effect on both the kink modes and ballooning mode. Nonlinear calculation shows that with the edge current increasing, the linear growth rate of the ELM size decreases. However, at the final saturated stage after the nonlinear evolution, the ELM size increases with the edge current. We studied the role the plasma geometry, by choosing the circular, elongated and shaped with X-point equilibrium. The shaped plasma and the X-point geometry has stabilizing effect on the ELMs. We benchmarked those calculation with other codes. 3D ELMs nonlinear simulation on EAST tokamak has first been studied, based on the discharge #41019. The result shows that there are four phases during one ELM crash, which gives us a vivid dynamic process of the ELM crash. We also prove the exactness of the nonlinear simulation by comparing the results of experiment and simulation, including the energy loss and speed of the ELM effluxes. The experimental energy loss of ELM crash is consistent with the nonlinear simulation within same order of magnitude. The speed of the simulated ELM effluxes is comparable with the experimental data by Gas Puffing Image (GPI) diagnosis, and the ELM crashes start at the outer mid-plane.

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