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TH/5-2Ra: Five-field Peeling-Ballooning Modes Simulation with BOUT++

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In this paper we report the simulations on ELMs with 5-field peeling-ballooning model using BOUT++ code. A minimum set of three-field two-fluid equations based on the peeling-ballooning (P-B) model with non-ideal physics effects is found to simulate pedestal collapse when using the BOUT++ simulation code [PRL, Vol 105, 175005 (2010)]. Based on this 3-field model, we investigate the effects of perturbed parallel velocity first. The perturbed parallel velocity can decrease the growth rate by 20.0%, and the energy loss caused by ELMs is decreased by 12.1%. After this work, in order to study the particle and energy transport at the pedestal region, we extend the previous two-fluid 3-field model of the pedestal collapse by separating the pressure into ion density, ion and electron temperature equations. Through the simulation, we find that the equilibrium density ni0 does not affect the normalized linear growth rate in the ideal MHD model because the dispersion relationship for normalized growth rate has nothing to do with density. With diamagnetic effects, the growth rate is inversely proportional to ni0. The reason is that the diamagnetic effects, which are inversely proportional to ni0, increase the threshold of the growth of perturbation. For the same pressure profile, constant T0 cases increase the growth rate by 6.2% compared with constant ni0 cases in ideal MHD model. With diamagnetic effects, the growth rate is increased by 31.43% for toroidal mode number n=15. This is because that the gradient of ni0 introduces the cross term in the vorticity equation. This cross term has the destabilizing effect on peeling-ballooning mode. For the nonlinear simulation, the gradient of ni0 in the pedestal region can increase the energy loss of ELMs and drive the perturbation to go into the core region. In order to simulate the recovering phase of ELMs, the edge transport barrier (ETB) is necessary. Therefore, besides the parallel viscosity, the parallel thermal conductivities of ions and electrons are also implemented into this 5-field model. The effects of thermal conductivity by employing flux limited expression will stabilize the growth of the turbulence and decrease the energy loss in the pedestal region. The more details will be discussed in this paper. This model can successfully be used for EAST tokamak. The simulations of EAST will be reported.

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