Contribution ID: **663**

Type: **Oral Presentation**

TH/5-2Ra & TH/5-2Rb: Five-field Peeling-Ballooning Modes Simulation with BOUT++; Theory and Gyro-fluid Simulations of Edge-Localized-Modes

Thursday, 11 October 2012 14:40 (20 minutes)

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

TH/5-2Rb: Theory and Gyro-fluid Simulations of Edge-Localized-Modes
This paper reports the theoretical and simulation results of a gyro-Landau-fluid (GLF) extension of the BOUT++ code which contributes to increasing the physics understanding of edge-localized-modes (ELMs). Large ELMs with low-to-intermediate-n peeling-ballooning (P-B) modes are significantly suppressed due to finite Larmor radius (FLR) effects when the ion temperature increases. However, small ELMs with an island of instability at intermediate n values are driven unstable due to (1) the ion drift wave resonance with a branch of the drift acoustic wave in a two-fluid model and (2) the Landau wave–particle resonances with thermal passing ions in a gyro-fluid model. This result is good news for high ion temperatures in ITER due to the large stabilizing effects of FLR. The simulation results are shown to be consistent with the two-fluid model including the ion diamagnetic drift for type-I ELMs, which retains the first-order FLR correction. The maximum growth rate is inversely proportional to Ti because the FLR effect is proportional to Ti. The FLR effect is also proportional to toroidal mode number n, so for high n cases, the P-B mode is stabilized by FLR effects. Nonlinear gyro-fluid simulations show results that are similar to those from the two-fluid model, namely that the P-B modes trigger magnetic reconnection, which drives the collapse of the pedestal pressure. Hyper-resistivity is found to limit the radial spreading of ELMs by facilitating magnetic reconnection. Due to the additional FLR-corrected nonlinear ExB convection of the ion gyro-center density, the gyro-fluid model further limits the radial spreading

of ELMs. Zonal magnetic fields are shown to arise from an ELM event and finite beta drift-wave turbulence when electron inertia effects are included. These lead to current generation and self-consistent current transport as a result of ExB convection in the generalized Ohm's law. Because edge plasmas have significant spatial inhomogeneities and complicated boundary conditions, we have developed a fast non-Fourier method for the computation of Landau-fluid closure terms based on an accurate and tunable approximation. The accuracy and the fast computational scaling of the method have been demonstrated. This work supported in part by the US DOE under DE-AC52-07NA27344, LLNL LDRD project 12-ERD-022 and LDRD project 11-ERD-058. LLNL-ABS-527551.

Country or International Organization of Primary Author

China

Primary authors: Mr XIA, Tianyang (China); XU, Xueqiao (Lawrence Livermore National Laboratory)

Presenter: Mr XIA, Tianyang (China)

Session Classification: Pedestal Stability and Control II

Track Classification: THD - Magnetic Confinement Theory and Modelling: Plasma–material interactions; divertors, limiters, scrape-off layer (SOL)