BOUT++ simulations of H-mode pedestal of tokamak devices[1]

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BOUT++ is a C++ framework for developing plasma fluid simulation codes. The code was based on the original 3D BOUndary Turbulence (BOUT) 2-fluid edge simulation code, which was first reported at the 6th International Workshop on Plasma Edge Theory. The aim of BOUT++ code development is to automate the common tasks needed for simulation codes, and to separate the complicated details such as differential geometry, parallel communication, and file input/output from the user-specified equation. The BOUT++ library represents a general framework for solving PDEs in curvilinear coordinates. Physics modules use defined functions to perform standard differential operators for different physics models. BOUT++ simulations have been successfully applied to edge turbulence, transport and blob dynamics in linear machines and toroidal systems, and edge localized modes (ELMs) in tokamaks.

In this work, we will also report BOUT++ simulations for H-mode pedestal instabilities and turbulent transport. To simulate pedestal stabilities, turbulence, and transport, and to validate with the corresponding experiments, the BOUT++ code uses realistic X-point magnetic and plasma profiles. The background magnetic field structure is obtained from the MHD equilibrium code EFIT. The plasma profiles (density, electron and ion temperature, parallel ion flow profiles) are obtained from experimental measurements. From a given discharge, the BOUT++ peeling-ballooning ELM model including electron inertia was used to analyze the ideal linear stability and ELM dynamics. The beta scan is carried out from a series of self-consistent MHD equilibrium generated from EFIT by varying pressure and/or current. For typical tokamak pedestal plasmas with high temperature and low collisionality, we found that the collisionless ballooning modes driven by electron inertia are unstable in H-mode pedestal, and have lower beta threshold than ideal peeling-ballooning modes, which are the triggers for Edge Localized Modes. The growth rate of electron inertia ballooning modes is found to increases with the magnitude of the electron skin depth $d_e=c/\omega_{pe}$. Thus, collisionless (electron inertia) ballooning modes might be responsible for H-mode turbulence transport when the pedestal is stable to peeling-ballooning modes.

[1] X. Q. Xu, and R. H. Cohen, ***Contributions to Plasma Physics*, 38**, (1998) no. 1-2, 158.

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