Multi-scale simulation study on ELM crash dynamics

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In H-mode plasma of Tokamak, the edge localized mode (ELM) is observed which releases the intermittent heat flux. In ITER, it is pointed out that the ELM should be avoided or mitigated to suppress the heat load on plasma facing components to allowable level. To understand the dynamics of intermittent energy release during ELM, the nonlinear simulation is indispensable. It is an important issue to develop the simulation technique for multi-scale ELM simulation, namely, the interaction between MHD and turbulent transport.

BOUT++ code employs field-aligned coordinates as well as flux surface coordinates for tokamak edge simulations [1]. The radial derivative method and the shifted metric method are combined to simulate ballooning mode instabilities with reasonable computational cost and high accuracy. It has provided qualitative understandings on ELMs triggered by middle-*n* ~ high-*n* ballooning modes [2].

There was a limitation to handle with the convective cell modes (n=0 modes, where n implies the toroidal mode number) in BOUT++ code which play a key role for turbulent transport after ELM crash. The two-dimensional Poisson solver for n=0 mode is implemented to resolve the limitation [3,4]. The simulation study on ELM crash triggered by the resistive ballooning mode with middle to high n mode numbers is performed [4]. The effect of convective cell modes on energy release process is investigated. It is found that during the primary ELM crash, the convective cell modes are driven by means of the Reynolds stress as well as of the residual of force balance for fluctuation. However, after the primary ELM crash, the latter is dominant. In this phase, the nonlinear periodic oscillation appears followed by the secondary instability which enhances the energy release.

This picture is somewhat different from the previous study where only zonal flow (m=0,n=0) is taken into account as the convective cell modes in vorticity equation without solving n=0 Ohm's law[5].

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