Divertor Heat Flux Based On BOUT++ and SOLPS

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China Fusion Engineering Testing Reactor (CFETR) is under conceptual design, acting as a bridge between ITER and DEMO. Scrape-Off Layer Plasma Simulation (SOLPS) code package is a fundamental tool for the design of CFETR divertor and for predictive simulations; therefore, a series of divertor design work has been performing by SOLPS code. SOLPS uses 2D fluid plasma model, including multiple ions and charge states, and comprehensive atomic reaction rates (ionization, radiation, etc). The classical transport is assumed parallel to magnetic field, with ad-hoc transport coefficients in the cross-field direction. Although it is one of the standard edge codes, major uncertainty in SOLPS and other edge transport simulations is the anomalous perpendicular transport coefficients used (not from first principles). The common practice is to adjust the perpendicular transport coefficients in order to fit midplane experimental plasma profiles.

In order to do consistent scrape-off-layer plasma transport calculations, the 2D fluid code SOLPS has been externally coupled to the 3D turbulence code BOUT++ for DIII-D and C-Mod. The basis of this method is the use of file I/O transfer between the codes being coupled. The coupling procedure is described as follow. (1) BOUT++ turbulence simulations are first performed for DIII-D and C-Mod discharges to get saturated turbulent particle and heat fluxes using experimentally measured midplane plasma profiles inside separatrix; (2) Given plasma density and temperature almost at the separatrix as boundary conditions, and surface- and time-averaged turbulent fluxes in the SOL, the SOLPS simulations are performed to obtain a steady state SOL plasma profiles and heat fluxes at divertor plates; (3) Compare the midplane plasma profiles and divertor heat fluxes with experimental measurements; (4) the SOLPS SOL plasma profiles are then used for BOUT++ turbulence simulations to check the convergence for possible impact on turbulence spreading in the SOL; (5) divertor gas puff and impurity injection will be performed in comparison with experimental divertor heat fluxes.

The nonlinear simulation results by BOUT++ 6-field two-fluid model show a reasonable agreement of turbulent heat flux onto outer divertor target with the experiment. Figure 1 shows that the simulated peak turbulent heat flux of C-mod slightly smaller than the experiment, while for DIII-D it is 3 times greater, possibly due to significant impurity radiation for DIII-D detached plasmas, which would decrease the heat flux in front of the target. For coupled simulations, the radial profiles of turbulent transport coefficients have been calculated including the neoclassical transport and turbulent transport, results will be presented.

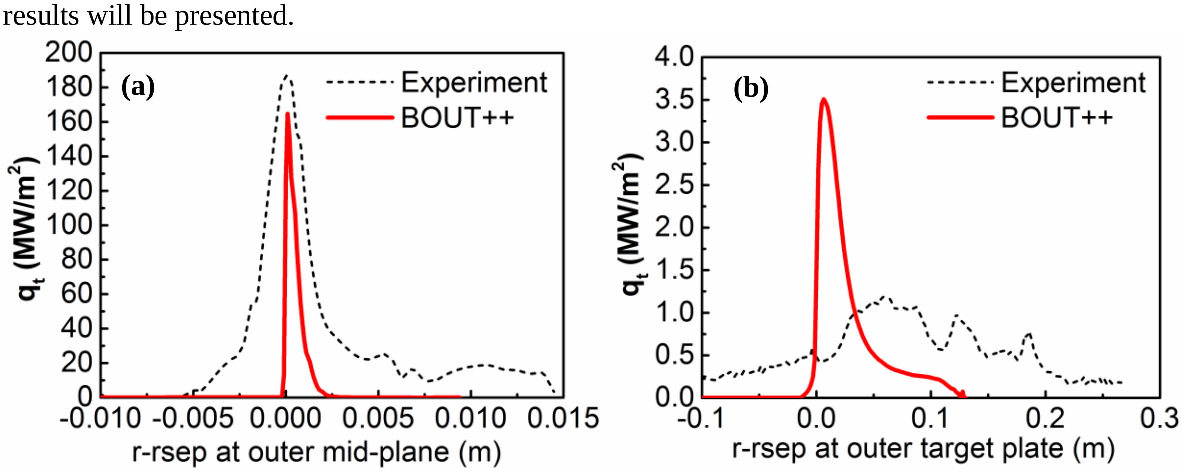

Fig. 1 The comparison of the radial distribution of heat fluxes to outer divertor target. (a): C-mod shot 1100223012, time-averaged from t=1.1000 to t=1.2000 sec; (b): D-IIID shot 158772, one peak ELM cycle. The black dashed

curves are for experiment, the red solid curves are for BOUT++ simulation.