§6. Research on Advanced Operation and Control for Fusion Core Plasmas — SOL-Divertor Simulation —

Ogawa, Y., Togo, S. (Fac. Frontier Sci., Univ. Tokyo)

In order to commercialize the tokamak fusion reactors, reduction of the divertor heat load is one of the most important issues. Detached plasmas can reduce the heat load dramatically, so that the mechanism of them is researched worldwide. For the quantitative prediction of the heat load on the divertor in the future devices, Scrape-off-layer (SOL)-Divertor (DIV) plasma code packages are utilized. The results of them, however, do not satisfactorily agree with those of experiments. We focus on the SOL-DIV plasma fluid model. Code packages are generally using the Braginskii's equations which assume that the temperature is almost isotropic. Due to this, the effect of pressure anisotropy is approximated by parallel viscous flux which makes the parallel momentum transport equation the second-order differential. Thus, the Mach number at the sheath entrance is required to be given as a boundary condition.

We developed a one-dimensional (1D) SOL-DIV plasma fluid code which introduces ion temperature anisotropy[1]. Since the parallel momentum transport equation becomes the first-order differential, the boundary condition on the Mach number at the sheath entrance becomes unnecessary. Instead, we developed and incorporated a virtual divertor (VD) model. In this model, an artificial region (VD region) with artificial sinks for particle, momentum and energy is set beyond the sheath entrance, as shown in Fig. 1. We derived the plasma fluid model with anisotropic ion temperature. By using a periodic boundary condition, treatment of the complex plasma-wall boundary in the real device becomes much easier. The validity of the VD model is demonstrated for the Bohm criterion and the sheath heat transmission factors. Some preliminary results by using the plasma fluid model are also presented about the anisotropy of ion temperature, supersonic flows due to radiative cooling and the validity of the viscosity approximation.

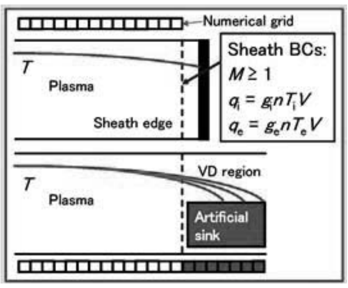

Fig. 1 Virtual Divertor model

The numerical model of neutral fluid is introduced which works with the VD model. This model is based on the first-flight corrected diffusion (FFCD) model, as shown in Fig. 2. The validity of the VD model is shown about the boundary condition for the diffusion neutrals. Some preliminary results are presented about the effect of neutrals on the ion temperature anisotropy and the modification of the diffusivity of neutrals.

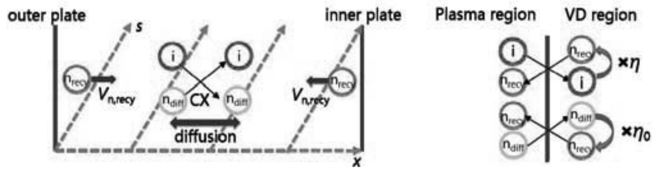

Fig. 2 Neutral model for Virtual Divertor model.

We show the results on the recombination detachment as an application of our code. We investigated the effect of supersonic flow on the transit from the attached to the detached regime. The formation of the low temperature and low density plasma near the sheath entrance is seen and roll-over of the particle flux amplification factor is reproduced. By introducing the effect of radial diffusive loss, we obtained the high recycling regime, as well. It is found that this effect makes the roll-over of the particle flux moderate. Figure 3 shows the particle and momentum flux amplification factors R_Γ and R_P, respectively, as a function of particle flux Γ_{sep} at the separatrix, where d and d_1 mean the SoL width and decay length of plasma parameters in SoL, respectively. By enhancing the impurity radiation, the motion of the detachment fronts was observed and supersonic flow generated near the sheath entrance although steady state solution is not yet obtained. The movement of the detachment front shows in Fig. 4(a) and (b).

[1] S. Togo, et al., J. Comput. Phys., **310** (2016) 109-126.

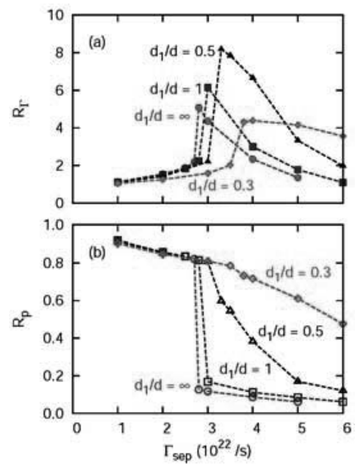

Fig. 3 particle and momentum amplification factor as a function of particle flux.

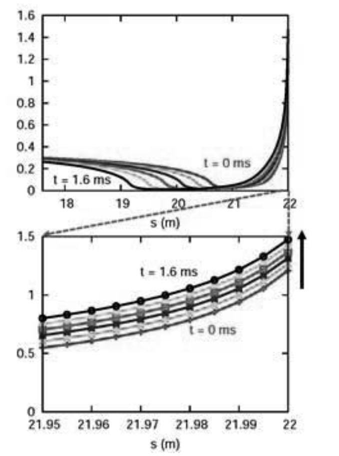

Fig. 4(a) Temporal evolution of Mach number at the detachment.

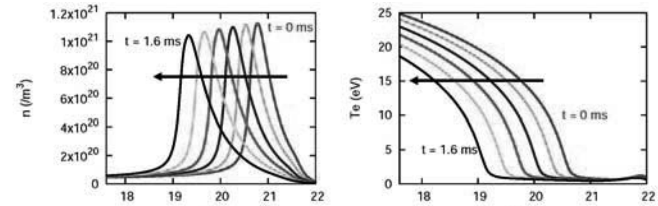

Fig. 4(b) Movement of detachment front.