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中性粒子がダイバータプラズマの非接触フロントの安定性に与える効果
Effects of Neutral Particles on the Stability of Detachment Fronts in Divertor Plasmas

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1. Introduction

Reduction of the divertor heat load is one of the crucial issues in designing next generation tokamaks such as ITER and DEMO. In order to resolve this issue, operation with detached divertor plasmas is considered to be a promising way [1].

In order to model SOL-divertor plasmas, two-dimensional (2D) codes, such as SONIC [2] and SOLPS [3], and point divertor models have been used. It is considered, however, that 2D codes are computationally massive to focus on studying each physical phenomenon in plasmas. On the other hand, point divertor models are very easy, but have not reproduced detached divertor plasmas so far. Thus one-dimensional (1D) codes [4, 5] have been used to gain physical insights of detached divertor plasmas.

In our previous works [6, 7], we adopted a simple model for the neutral particles assuming that the neutral flux decays exponentially due only to ionization reaction. In the presentation, we will show the effects of neutral particles on the detachment fronts by introducing a time-dependent neutral model. Here we show some preliminary results in the attached regime.

2. Model

The 1D divertor model we use analyses a SOL-divertor plasma along the magnetic field. Refer [6, 7] for detailed explanations of geometry, plasma fluid equations and the boundary conditions.

The neutral model we have introduced instead of the simple one is described as follows;

$$\frac{\partial n_n}{\partial t}+\frac{\partial}{\partial s}\left\{\alpha\left(n_n v_{FC}\right)+\beta\left(-\lambda_{CX} v_{th}\frac{\partial n_n}{\partial s}\right)\right\}+\frac{n_n}{\tau_n} \quad (1)$$
$$=n_i n_e \langle\sigma v\rangle_{rec}-n_n n_e\langle\sigma v\rangle_{ion},$$

$$\Gamma_{n,us}=0,\quad \Gamma_{n,dp}=\eta_{trap}\Gamma_{i,dp}\,. \quad (2)$$

Equation (1) is the particle conservation equation. The coordinate s is in the poloidal direction. We can choose the transport model from the convection model and the diffusion model considering the charge exchange reaction [8] by switching the value of (α,β) as $(1,0)$ or $(0,1)$. The third term in the LHS is the particle loss term whose time constant τ_n is a free parameter. Equations (2) represent the boundary conditions. The parameter η_{trap} is the recycling rate of the ion flux.

3. Results

The steady state neutral density profiles for different transport mechanisms when τ_n is set to be infinity are shown in Fig. 1 (a). The mean free path of neutral particles becomes longer in the diffusion case due to charge exchange reaction. The effect of the loss term is shown in Fig. 1 (b). When τ_n is short enough to be comparable with the time constants of the diffusion term and source terms, the neutral density becomes lower.

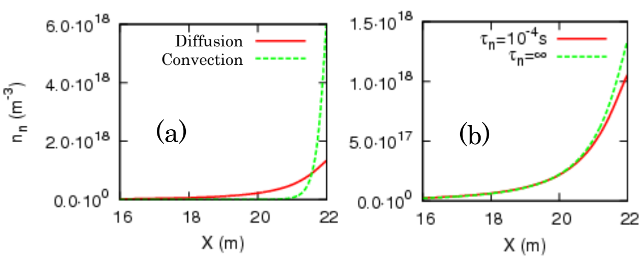

Fig. 1 Steady state neutral density profiles for different transport mechanism when τ_n is set to be infinity (a) and those for different values of τ_n in the diffusion case (b).

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