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熱パルスに対するデタッチメントプラズマの動的応答解析
Analysis of dynamic response of the detachment plasma to heat pulse

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Plasma detachment is thought to be one of the most effective methods to reduce the plasma heat flux to the divertor. Atomic and molecular processes such as three-body recombination and molecular activated recombination(MAR) play an essential role in detached plasmas[1]. On the other hand, plasmas of high temperature and density due to the heat pulse by the edge localized mode(ELM) can cause a collapse of steady-state detachment state. In the ELMs, the energy distribution of plasma deviates from thermodynamic equilibrium. Therefore, a kinetic model is needed to analyze the ELM. Our final goal is to develop a self-consistent kinetic model of plasma and neutral interaction.

As a first step, we developed a 0D model considering atomic and molecular processes :

$$\frac{\mathrm{d}n_i}{\mathrm{d}t} = \sum_{j,k} R_{\mathrm{gain}} n_j n_k - \sum_{l,m} R_{\mathrm{loss}} n_l n_m - \frac{n_i}{\tau_{\mathrm{trans}}} + S_{\mathrm{gain}}, \tag{1}$$

where n is particle density, indices i, j, k, l, m are particle species(e, H^+, H^-, $\mathrm{H_2}^+$, H, $\mathrm{H_2}$), $R_{\mathrm{gain}}, R_{\mathrm{loss}}, \tau_{\mathrm{trans}}, S_{\mathrm{gain}}$ is, respectively, the rate coefficient of particle i via production processes, via extinction processes, confinement time, and other production of density such as gas puff of $\mathrm{H_2}$ and recycling of H. This model takes into account radiative/three-body recombination, MAR, excitation/deexcitation/spontaneous radiation/ionization of H, dissociation of $\mathrm{H_2}^+$, and loss of H^-. In Eq. (1), the rate coefficient $R_{\mathrm{gain}}, R_{\mathrm{loss}}$ is given by :

$$R = \int \sigma(E) v(E) f(E) dE, \tag{2}$$

where $\sigma(E)$ and $v(E)$ is, respectively, the cross section of the reaction and relative velocity of particles involved in the collision events. The distribution function $f(E)$ during the ELM possibly deviates from Maxwellian.

To test the model, we firstly assumed $f(E)$ as a Maxwellian with T_e = 1eV and 10eV in Eq. (2). We calculated the time evolution of ion flux in T_e = 1eV and 10eV, as shown in Fig. 1. The ion flux strongly decreases in 1eV compared to 10eV which suggests the formation of detached plasma in 1eV. Therefore, we confirmed steady-state detachment in a 0D model simulation assuming Maxwell distribution.

The calculation from non-Maxwellian and the response to the heat pulse are explained in poster session.

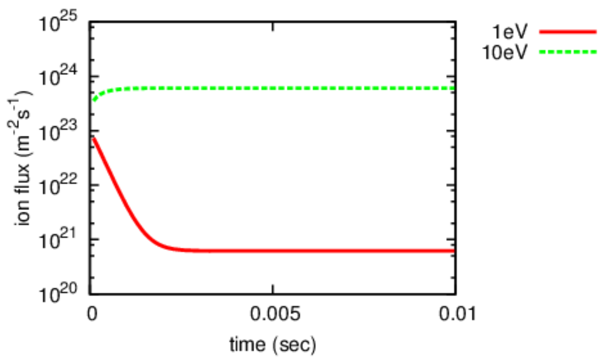

Fig.1 Time evolution of ion flux in 1eV and 10eV

[1] A.Yu. Pigarov, S.I. Krasheninnikov, D.J. Sigmar, Phys. Lett. A **2**14(1996) 285.