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A fluid simulation approach to study the plasma detachment in GAMMA 10/PDX

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The divertor simulation research has been focused of attention in order to reveal the detailed physical mechanism of plasma detachment such as radiation cooling, impurity transport, volume recombination processes (MAR and EIR). Neutral gas seeding in the divertor region could significantly reduce the plasma energy by increasing the plasma energy loss terms such as charge-exchange loss, radiation loss and ionization loss. Therefore, the divertor simulation research has been conducted in the end-cell of GAMMA 10/PDX to explore the physical mechanism related to the divertor plasma physics [1].

A numerical simulation study by using the multi-fluid code "LINDA" has been started in the end-cell of GAMMA 10/PDX for understanding the detailed physical mechanism of plasma-neutral interactions such momentum loss, charge-exchange loss, ionization loss, radiation loss, recombination loss. The LINDA (Linear Divertor Analysis with fluid model) code is a 2D multi-fluid code which consists of continuity equation, momentum equation, energy equation for ions and electron [2-3]. The mesh structure of the simulation space has been designed according to the magnetic field configuration of GAMMA 10/PDX. A tungsten target plate has been assumed to be located at the end of the simulation space.

In order to study the recombination processes, the upstream boundary conditions are imposed as $T_e = T_i$ (x=0, y=0) = 5 eV. The divertor boundary conditions are applied on the target plate. The neutral hydrogen gas has been injected from the end of the simulation space and the gas is transported toward the upstream region. The source terms of the fluid equations represent energy loss processes during plasma-neutral interaction. The hydrogen neutral profile has been defined by using the 1D fluid equation in the self-consistence manner.

In this paper, the effect of recombination processes (MAR, radiative and three body) on the plasma detachment has been investigated by using the LINDA code. Figure 1 (a) shows the dependence of the ion and electron temperature as a function of the hydrogen neutral density. It is found that ion temperature reduces with the increasing injected neutral density (n_{inj}). However, the electron temperature did not reduce with the increasing hydrogen neutral density. The effect of recombination processes on the electron and ion temperature has not been observed. On the contrary, a significant difference has been observed in the plasma density between with and without recombination as shown in Fig 1(b). For without recombination process, the electron density continues to increase with the increasing neutral density. On the other hand, the electron density becomes saturated at the higher neutral density in the case of recombination processes. These outcomes represent the role of recombination processes to generate detached plasma.

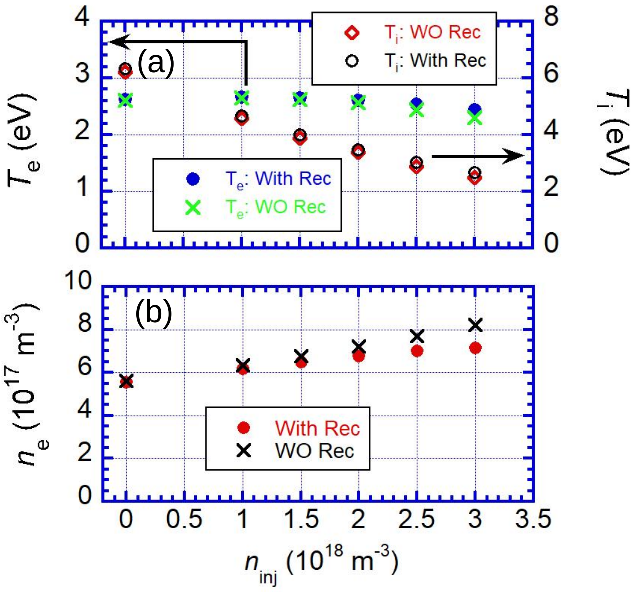

Fig. 1. Dependence of plasma parameters on the target plate at r=0 (a) electron and ion temperature, (b) electron density as a function of injected hydrogen neutral density (n_{inj}).

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