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プラズマ非接触過程の粒子シミュレーション
Particle Simulation of the Plasma Detachment Process

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Detached plasma [1] has been proposed as an effective way to reduce the divertor heat load. Atomic processes play a crucial role in the detached plasma. In the experiment, the detached plasma occurs when there is a high recycling rate near the divertor plate. This high recycling rate divertor increases the ion-neutral collision rate and decreases the plasma temperature. Neutral gas puffing also increases the neutral density near the divertor and decreases the plasma temperature. Sometimes the impurity is injected for the radiative loss.

Fluid code has been widely used to investigate the detached plasma but the cooling of plasma, trapped particle effects, and other kinetic dynamics in the detached plasma has not been well understood. Particle-in-Cell (PIC) simulation with the Monte Carlo collisions [2] and the cumulative scattering angle coulomb collision [3] are carried out to study dynamical kinetic behavior of the plasma.

The simulation is carried out by assuming the constant pressure and temperature neutral gas box in front of the divertor plate. The real ion-electron mass ratio is used, m_i/m_e = 1836. The simulation system size is L = 0.2 m and the neutral gas box region is L_N = 0.05 m. The upstream plasma density is n_u ~ 3×10^{18} m^{-3}. Since there is the density threshold for plasma detachment in gas target [4], this means that the Coulomb collision frequency becomes important for the plasma detachment. In this simulation the plasma density and system size are too small for the detached plasma to be observed, thus the Coulomb collision frequency has been modified $\nu_c=100\nu_{c0}$. The upstream plasma density is fixed, thus the source particle flux can be varied in time.

By varying the neutral gas pressure, P_N, the simulations results show the sharply decrease in electron temperature in front of the divertor plate (Fig. 1). By increasing the neutral gas pressure the total heat flux is reduced by 2 orders of magnitude at P_N = 10 mTorr (Fig. 2). The electron density and temperature dependence in front of the divertor target are shown in Fig. 3.

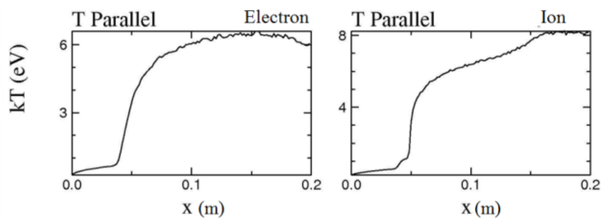

Fig. 1. Electron and Ion temperature profile along the field line at P_N = 10 mTorr.

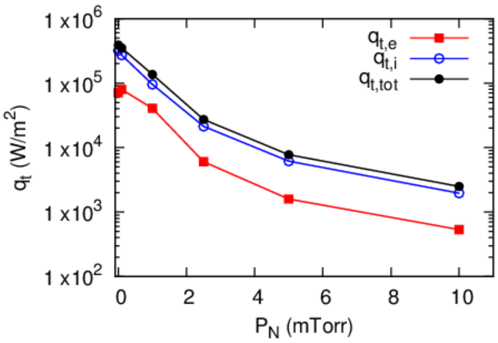

Fig. 2. Divertor heat load vs. neutral gas pressure.

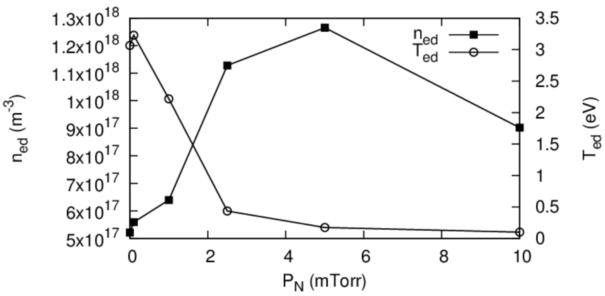

Fig. 3. Dependences of n_{ed} and T_{ed} with P_N.

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