# §25. Strong Temperature Gradient in Detached Plasma

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Detached plasma is a method of reducing the heat load to the divertor plate of fusion devices. Most of the theoretical and numerical works deal only with steady state. Combination of plasma kinetic physics and atomic processes such as line radiation, ionization, charge-exchange collision and recombination might play important roles in the detachment plasma behavior.

In order to investigate dynamical kinetic behavior of the detached plasma, which is caused by gas puffing to achieve the reduction of divertor heat load, we are developing a high-performance one spatial dimension and three velocity space (1D3V) Particle-in-Cell(PIC) simulation with the Monte Carlo collisions, where spatial and velocity space distributions of charged particles, self-consistent electric field created by charged particles, the Coulomb binary collision and atomic processes such as ionization and charge exchange are included.

In Fig. 1, schematic of simulation model is presented. While plasma source region is placed in the right hand side, plasma absorbing plate corresponding to the divertor is placed in the left hand side boundary. Neutral gas is assumed to be supplied in the gas box placed in the left hand side of the system and atomic processes take place there. The external magnetic field with 1Tesla is pointing into the negative x-direction.

Simulation parameters used in this work are as follows: The system size is 0.2m. The ion to electron mass ratio is 1836. The ion and electron source temperature is 10eV. The neutral gas temperature is 0.026eV, which is the room temperature.

Initially, the ion and electron pair are injected with constant rate in time. However, in order to keep the fixed upstream density, when $n_u$ is greater than $3x10^{18}$ $m^{-3}$, no particles are injected to the system and the particles in the source region are heated.

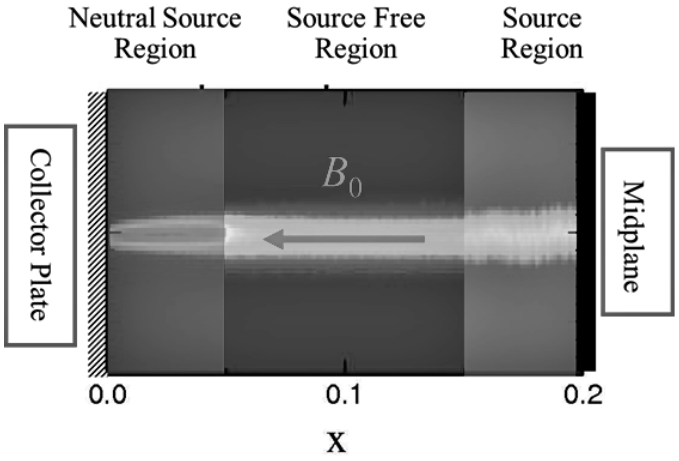


Fig. 1. Simulation model for detached plasma simulation.

In our simulation, the system size and the plasma density are much smaller than those of the detached plasma experiment[1]; thus we employ a hundred times amplified Coulomb collision frequency.

The ion and electron temperature profiles with the neutral gas pressure 0mTorr(top), 1mTorr(middle) and 10mTorr(bottom) are shown in Fig. 2. In the case with 10mTorr, strong temperature gradient is observed in the gas box[2]. Ions lose their energy due to elastic and charge exchange collision with neutral particles. The transfer of the electron kinetic energy to the ion kinetic energy is mainly caused by the Coulomb collision[3].

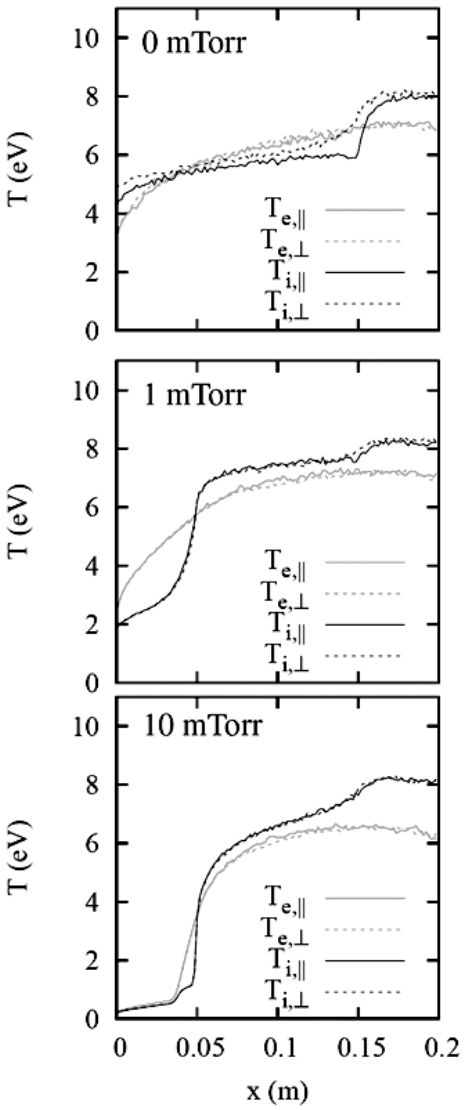


Fig. 2. Spatial profiles of ion and electron temperature.

1) Hsu et al., Phys. Rev. Lett. 49, (1982) 1001.
2) Pianpanit, T., et al: Plasma and Fusion Res. **11** (2016) 2403040.
3) Ezumi, N. et al., Nucl. Mater. **241-243** (1997) 349. .