§7. Particle Simulation on Detached Plasma

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A self-consistent kinetic particle simulation model for studying plasma behavior in divertor region is developed. This simulation model is applied to study a formation of detached plasma at a divertor region. A detached plasma condition has been experimentally observed just before divertor or target plate by means of intense injection of neutral particles.1,2) In this condition plasma temperature was decreased until lower than 1 eV and three body recombination was understood as dominant mechanism of reduction of heat input. In order to study this phenomena a self-consistent kinetic simulation model on one dimensional collisional bounded plasma is presented. The electrostatic potentials are obtained by solving Poisson's equation and collisions among particles, which include charged particles and neutral particles, are calculated by means of Monte Carlo method. The excitation and ionization of neutral particles and recombination of plasma particles as well as charge exchange process are taken into account in this model.

The typical parameters of simulation runs are listed in Table.1. The spatial profiles of temperatures of plasma and neutral particles and electron density at time 6000 is shown in Fig.1. The positions $x = 0$ and 800 indicate the symmetric boundary and the target or divertor plate, respectively. The preliminary results of one dimensional simulation show the plasma detachment is formed in front of an target/divertor plate by intense injection of neutral particles with temperature of 0.027 eV. The plasma temperature at the detached region sharply drops from the background one of 2.0 - 3.0 eV to around 1.0 eV. At the detached region heat power of injected electrons is transferred to plasma ions due to Coulomb collisions and finally it is removed by charge exchange process. This temperature, however, is higher than that where the three body recombination loss process becomes dominant. The detailed quantitative investigations such as power balance as well as the deviation from Maxwellian velocity distribution are left as future issues. The effects of molecular to the recombination process, MAR (Molecular Activated Recombination), should be included in this model.

system length (L):	800 λ_{De}
mesh size:	λ_{De}
time step:	$0.1 / \omega_{pe}$
mass ratio m_i / m_e:	400
initial background plasma:	
density:	3×10^{13} cm^{-3}
electron temperature:	6.0 eV
ion temperature:	3.0 eV
number of electrons or ions:	40000
source plasma:	
injection region:	[0 , 0.1L]
injection number of source electrons or ions every time step:	$1 / \omega_{pe}$
electron temperature:	15.0 eV
ion temperature:	7.5 eV
neutral particles:	
injection region:	[0.1L , L]
injection number every time step:	300
temperature:	0.027 eV (= 300 K)

Table I. Typical simulation parameters

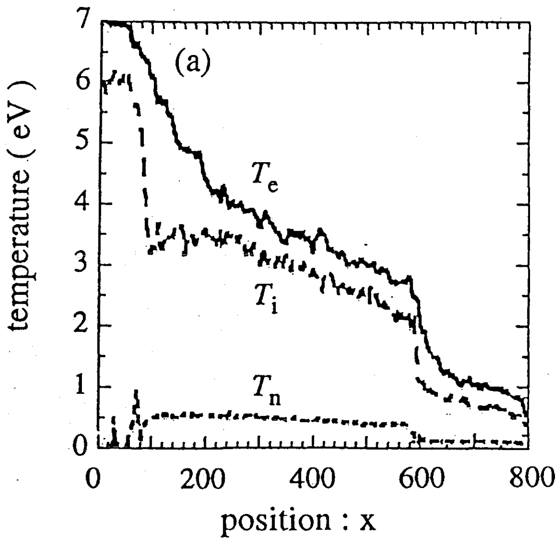

Fig. 1. The spatial profiles of temperatures of plasma and neutral particle (a), electron density (b) at time t = 6000. The detached plasma is observed between x = 600 and 800.

Reference

1) N.Ezumi et al., J. Nucl. Mater. **241-243**, (1997) 349.

2) D.Lumma et al., Phys. Plasmas **4**, (1997) 2555.