§13. Gas Target Experiments in High Heat Flux Plasma of the TPD-I Device

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Studies of the physics of the divertor plasma remain a high -priority part of the controlled fusion programs. It is so important to reduce the heat load to the divertor plate for the next generation fusion devices such as LHD, intended to have long pulse and steady state operation. The gas target divertor concept is one of the most important candidates[1-4]. In order to make more detailed investigations on the gas target, it is necessary to produce higher heat flux plasmas relevant to the SOL conditions in large devices. The TPD-I device is able to generate high density $\sim 6\times10^{19}\mathrm{m}^{-3}$ and high heat flux $\sim 20\mathrm{MW/m}^2$ helium plasma.

Gas target experiments are performed by feeding a secondary helium gas into the plasma test region. Figure 1 shows the dependence of the radial profiles of electron density n_e and temperature T_e on the gas pressure P. The T_e is generally cooling from 10eV to 2eV with an increase in P and remains constant above $P \sim$ 5.3mtorr. On the other hand, n_e increases at first and abruptly decreases above $P \sim$5.3mtorr. These experimental results indicate that at $P \sim$5.3mtorr, the ionization front reaches the position at which the fast-scanned probe is mounted. A cushion plasma with cold electrons is thought to be generated between the target plate and the probe. Concerning the electron temperature profile, T_e decreases radially from the plasma center outwards at $P \sim$ 1.3mtorr. In contrast, the profile of T_e becomes hollow at higher gas pressure. In the plasma at $P \sim$ 12.5mtorr corresponding to the 'cushion regime', the electron density and temperature are observed to be reduced by a factor of ten and five, respectively. We compare the experimental results with the simulation results obtained from the 2D plasma fluid B2 code [5,6]. Figure 2 shows the dependence of the radial profile of T_e on P, predicted with the B2 simulation. The predicted profile change from peaked to hollow agrees well with that measured experimentally as shown in Fig. 1. Electrons are cooled due to ionization and radiation losses, which provide no change of radial profile of electron temperature because the energy loss per electron is the same in the center and at the periphery. In addition to these losses, another loss of the electron energy associated with the charge exchange loss between ions and neutrals occurs due to a strong electron-ion energy coupling, which leads the hollow profile of electron temperature because the electron-ion energy coupling is stronger at the plasma center than at the periphery.

Reference

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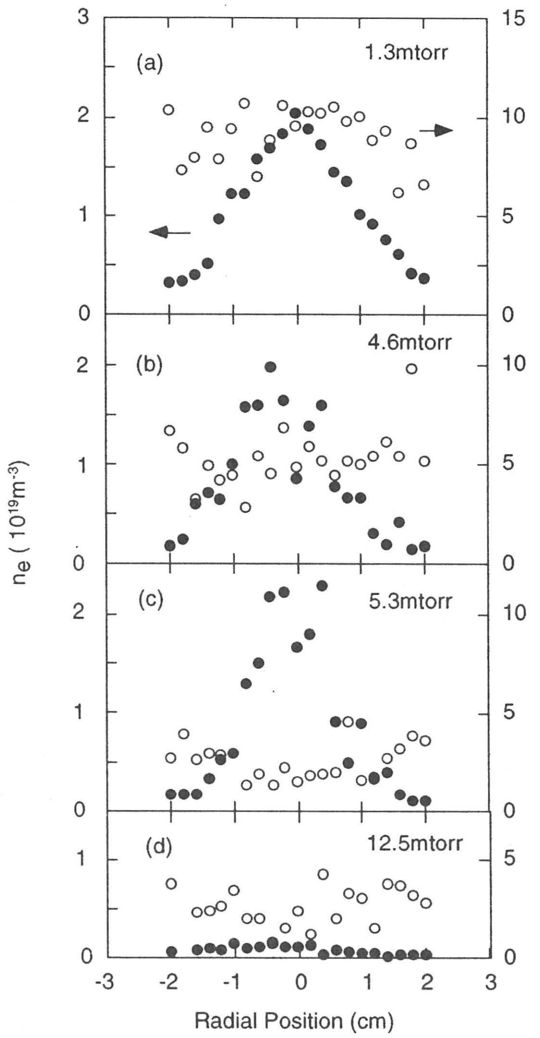

Fig. 1 Dependence of the profiles of n_e and T_e on a gas pressure P ; (a) 1.3mtorr, (b) 4.6mtorr, (c) 5.3mtorr, (d) 12.5mtorr. Closed and open circles are n_e and T_e, respectively.

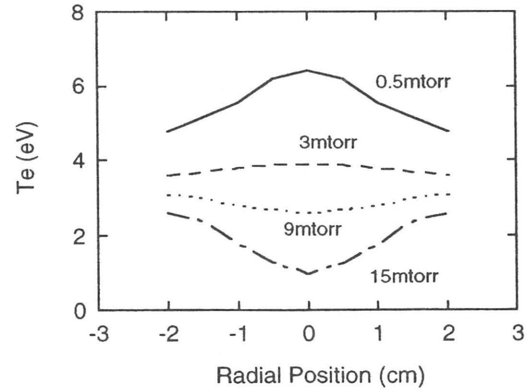

Fig. 2 Dependence of the radial T_e profile on P, predicted with the B2 simulation.