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Electron Temperature and Density Distributions in Detachment Experiments on a Divertor Simulation Experimental Module of GAMMA 10/PDX

GAMMA 10/PDX のダイバータ模擬実験モジュールにおける
デタッチメント実験時の電子温度・密度分布

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Distributions of electron temperature T_e, density n_e and ion saturation current I_{is} are measured in detachment experiments with H_2 and impurity (Xe) gas injection on a divertor simulation experimental module of GAMMA 10/PDX. As Xe gas is increased, T_e and I_{is} decrease but n_e once increases and then decreases especially near the target plate, which suggests the detachment. At high Xe gas amount, the region where n_e compensated for magnetic flux expansion decreases toward the target plate appears, which suggests recombination is dominant.

1. Introduction

Radiation cooling and the detachment in the divertor to reduce heat load are important issues for a fusion reactor [1]. However, physical mechanism of the detachment has not been sufficiently understood [2]. Therefore, we study radiation cooling and the detachment utilizing high temperature (electron ~ 100 eV, ion ~ 10 keV [3]) core plasma of tandem mirror device GAMMA 10/PDX [4-6]. Recently, a divertor simulation experimental module (D-module) has been installed in GAMMA 10/PDX [7,8].

Plasma temperature and density distributions including magnetic field direction are important for the detachment study [9]. Thus, in this study, electron temperature and density distributions are measured in detachment experiments with gas injection on the D-module.

2. Experimental Apparatus

Figure 1 shows a schematic view of GAMMA 10/PDX and the D-module. The D-module has a tungsten V-shaped target plate (open-angle of 45 degree in this work), H_2 gas injection ports, impurity gas (Ar, Xe, Ne, N_2, etc.) injection ports, and a closed divertor structure, which are useful for the radiation cooling and detachment study.

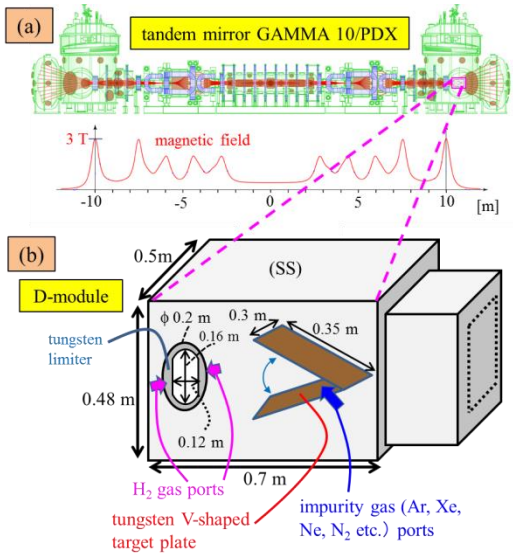

Fig.1. Schematic of GAMMA 10/PDX and D-module.

3. Experimental Results and Discussion

Figure 2 shows distributions of electron temperature T_e, density n_e and ion saturation current I_{is} measured by Langmuir probes in H_2 and Xe gas injection experiments. T_e decreases from ~ 15 eV to ~ 5 eV at the inlet and from ~ 6 eV to ~ 2 eV at the target plate by Xe gas injection. n_e once increases by medium Xe gas injection of 50 kPa (plenum pressure) especially near the inlet side and then

decreases by high Xe gas injection of 100 kPa especially at the target plate. I_{is} decreases by Xe gas injection and the decrease rate is higher near the corner of the target plate than the inlet. These phenomena suggests the detachment.

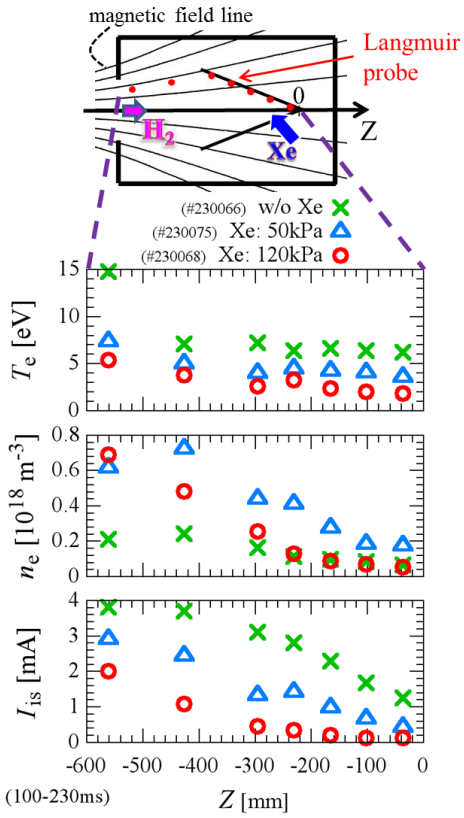

Fig.2. Distributions of T_e, n_e and I_{is} measured by Langmuir probes in H_2 and Xe gas injection experiments on the D-module (plenum pressure of H_2 is 100 kPa).

Figure 3 shows distributions of T_e and n_eS along magnetic field line direction measured by the three probes between the inlet and the target plate in the same H_2 and Xe gas injection experiments, where S is a compensation factor for magnetic flux expansion (S is also cross-sectional area of a magnetic flux tube at the probe position). Without Xe gas, n_eS increases toward the target plate, which suggests ionization is dominant than recombination. With Xe plenum pressure of 50 kPa, n_eS becomes larger, which indicates more ionization due to Xe gas. With more Xe gas of 120 kPa, n_eS becomes smaller and the region where n_eS decreases toward the target plate appears in front of the target plate (-420 mm < Z < -300 mm), which suggests recombination is dominant. Moreover, ionization front (peak of n_eS) seems to move to the upstream side with increase of Xe gas. These phenomena is considered to be related to decrease of T_e.

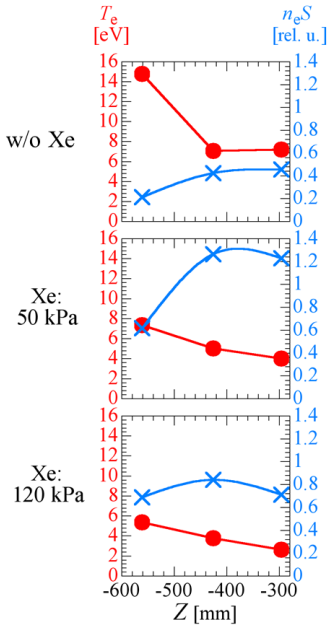

Fig.3. Distributions of T_e and n_eS along magnetic field line direction in the H_2 and Xe gas injection experiments.

4. Summary

T_e, n_e and I_{is} distributions are measured in detachment experiments with H_2 and Xe gas injection on the D-module. As Xe gas is increased, T_e and I_{is} decrease but n_e once increases and then decreases especially near the target plate, which suggests the detachment. And in high Xe gas amount, the region where n_eS decreases toward the target plate appears, which suggests recombination is dominant in front of the target plate.

Acknowledgments

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