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Measurement of electron temperature and density using HeI line intensity ratios in divertor simulation experiments on GAMMA 10/PDX
GAMMA 10/PDXでのダイバータ模擬実験におけるHeI線強度比法を用いた電子温度・電子密度計測

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In the tandem mirror device GAMMA 10/PDX, divertor simulation experiments have been carried out by using the divertor simulation experimental module (D-module). The electron density and temperature of the divertor simulation plasma have been measured simultaneously with a HeI line intensity ratio method.

1. Introduction
In a fusion device, reduction of the heat load on divertor plates is one of the most important issues. The radiation cooling of the divertor plasma and the subsequent divertor detachment are effective for the reduction of the heat load. In order to control the divertor detachment, it is important to understand the divertor phenomena. The purpose of this study is to measure electron temperature (T_e) and electorn density (n_e) of the divertor simulation plasma by using HeI line intensity ratio method.

2. Theoretical model
The population density ($n(p)$) of a level p is written with the following equation:

$$n(p)=R_0(p)n_e n_i+R_1(p)n_e n(1), \qquad (1)$$

where n_i is ion density. $R_0(p)$ and $R_1(p)$ are the reduced population coefficients and they are functions of n_e and T_e. The first term of the right hand side of eq.1 expresses a recombination component, and the second term expresses an ionization component. In GAMMA 10/PDX, T_e is high enough to ignore the recombination component. So, eq.1 is written with:

$$n(p)= R_1(p)n_e n(1). \qquad (2)$$

By using eq.2, a transition intensity ratio is described with:

$$\frac{I_{ij}}{I_{kl}}=\frac{A_{ij}n(i)}{A_{kl}n(k)}=\frac{A_{ij}R_1(i)}{A_{kl}R_1(k)}. \qquad (3)$$

In eq.3, I_{ij} is a transition intensity from i to j state, and A_{ij} is a transition probability from i to j state. In HeI line intensity ratio, it is known that intensity ratio change for electron temperature and density. Therefore, electron temperature and density can be evaluated from various intensity ratios.

3. Experimental Setup
The divertor simulation experimental module (D-module) has been installed in the west-end region of GAMMA 10/PDX. The D-module consists of a rectangular box (0.5 m square and 0.7 m in length) with an inlet aperture at the front panel and a V-shaped target inside the box as shown in Fig.1. In the upper side target, there is a nozzle for the He gas injection. And also there are two nozzles for the hydrogen gas injection toward the V-shaped target. Three HeI lines (λ=667.8 nm, 706.5 nm, 728.1 nm) have been measured by photomultiplier tubes with interference filters. In order to evaluate the electron temperature and density of the divertor simulation plasma, two HeI line intensity ratios, I(728.1 nm)/I(706.5 nm) and I(667.8 nm)/I(728.1 nm) have been utilized. HeI line intensity have been measured at two positions of which distance from the corner of V-shaped target is 200mm (No.1) and 150mm (No.2), respectively.

In this study, we measured the HeI line intensities in two cases of the hydrogen gas injection (plenum pressure of 200 mbar and 300 mbar).

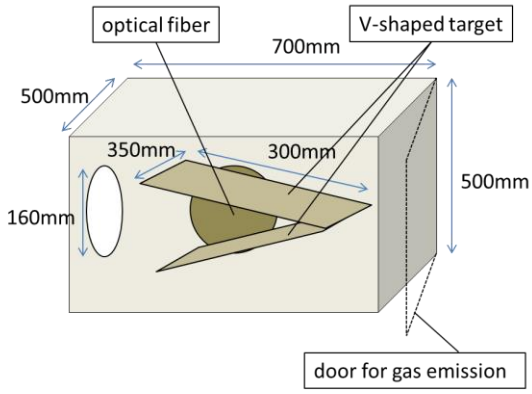

Fig.1 Schematic view of the D-module

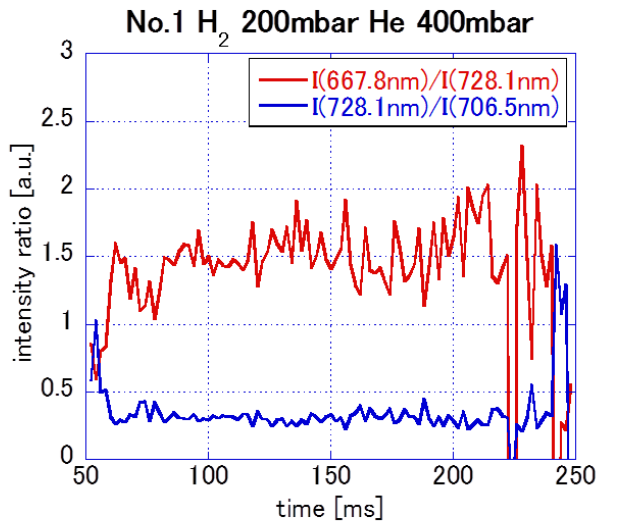

Fig.2 Time evolution of the HeI line intensity ratios. (plenum pressure of He:400mbar)

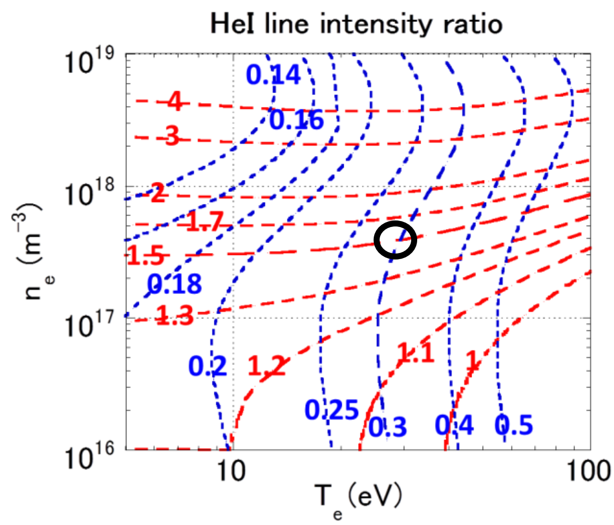

Fig.3 Contour map of the HeI line intensity ratios. Red line is for I(667.8nm)/I(728.1nm) and blue line is for I(728.1nm)/I(706.5nm))

4. Results

Figure 2 shows the time evolution of HeI line intensity ratios when plenum pressure of hydrogen is 200 mbar. The measurement position is No.1. The value of I(667.8 nm)/I(728.1 nm) is about 1.5, and that of I(728.1 nm)/I(706.5 nm) is about 0.3.

Figure 3 shows contour lines of two HeI line intensity ratios. The black circle shows the measured intensity ratio. Using this contour map, T_e and n_e have been evaluated to be ~30 eV and ~3 $\times 10^{17}$ m^{-3}.

In Table 1, results of the measurement is summarized. when plenum pressure of hydrogen is high, The electron temperature became lower at the measurement position closer to the corner of the target. On the other hand, the electron density became higher at the measurement position closer to the corner. The reason why the density became higher at the measurement position closer to the corner is under consideration.

Table 1 Electron temperature and density

H_2 plenum pressure (mbar)	Measurement position	T_e (eV)	n_e (m^{-3})
200	No.1	30.2	3.7×10^{17}
	No.2	18.8	1.3×10^{18}
300	No.1	21.2	5.6×10^{17}
	No.2	12.3	2.1×10^{18}

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References

[1] M. Goto, Journal of Quantitative spectroscopy & Radiative Transfer, 76 (2003) 331.