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H/He Partial Pressure Measurement by the Penning Gauge Spectroscopy in the Divertor Region on LHD

LHD ダイバータ領域におけるペニング真空計分光による水素・ヘリウム分圧計測

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Two penning gauge spectroscopy systems are installed on the Large Helical Device (LHD) in order to evaluate the helium compression ratio at the divertor region with and without the baffle structure. The intensities of H_α and the line emission from He I in the penning gauge discharges are compared. The initial calibration result shows that the partial pressure of helium at the divertor region with the baffle structure is higher than that at the position without the baffle structure by almost one order.

1. Introduction

The compression ratio of helium at the divertor region is important for the helium exhaust in a fusion reactor. On the Large Helical Device (LHD), two of ten torus inboard side divertors have the baffle structure [1]. In order to evaluate the helium compression ratio at the divertor region with and without the baffle structure, two penning gauge spectroscopy systems are newly installed to the torus inner ports of LHD. The penning gauge spectroscopy can measure the partial pressures of neutral gases at each local position from the spectroscopic observation of the penning discharge inside the gauge. This diagnostic was developed at TEXTOR in order to distinguish the partial pressures of deuterium and helium [2, 3]. It is also used for the the helium exhaust study on JET [4].

The penning gauge spectroscopy is first installed on LHD at 2004. Since it is located at the upper port, it mainly measures the peripheral pressure of the vacuum vessel.

2. New penning gauge spectroscopy system

Two penning gauges are installed at the torus inner ports of LHD. One is located at the baffle structured divertor and the other is located at the divertor region without the baffle structure. The same type (Leybold PR36) of the gauge heads are used and the high voltage from the same power supply is used for them. Although the penning gauge originally has permanent magnets of about 0.13 T in order to make the magnetic field for the penning discharge, the permanent magnets are removed because the magnetic field strength at the torus inside is up to about 2 T when the magnetic field strength at the magnetic axis, $B_{\rm ax}$, is 2.75 T. It is possible to start penning discharge with the magnetic field of LHD. The dependence of signal intensity on the magnetic field strength is small at the region of $B_{\rm ax} \geq 2$ T.

The light in the penning gauges are transferred to the visible spectrometer by optical fibers. The signals from two different positions are simultaneously detected by a CCD camera. As the wavelength range is about $580 \sim 730$ nm, H_α and 4 lines of He I are observed in this range. For the helium partial pressure, the He I line of 667.8 nm is used. The time resolution is usually 200 ms for high density plasmas and 500 ms for low density plasmas.

3. Experimental results

Figure 1 (g) $\sim$ (j) show an example of the comparison of the helium compression ratio between with and without the baffle structure. This plasma was heated by the neutral beam injection (NBI) and the averaged electron density was almost $6 \times 10^{19}\,\mathrm{m}^{-3}$ (Fig. 1 (a, b)). The helium gas was injected by the super-sonic gas-puff (SSGP) at $t = 3.8\,\mathrm{s}$ during the hydrogen gas was puffed (Fig. 1 (c, d)). Two signals of the ASDEX-type fast ion gauges are shown. One is the signal at the divertor region without the baffle structure (Fig. 1 (e)) and the other is the signal at the baffle structured divertor region (Fig. 1 (f)). These signals are sum of the hydrogen and helium pressures.

The signal intensity is derived by integrating in the wavelength range where the line signal appears. For both of H_α and the He I (667.8 nm) line, the signal intensities of penning gauge spectroscopy at the baffle structured divertor is higher than those of the position without the baffle structure by about one order. Since the signal intensity in Fig. 1 (h) is small, it should be noted that the intensity below 20 is almost same as the noise level. The calibration for deriving the pressure was made by filling hydrogen or helium gas and changing their pressure in the vacuum vessel. From the initial calibration results, the maximum helium partial pressure values in Fig. 1 are 4.9×10^{-3} Pa for Fig. 1 (h) and 5.2×10^{-2} Pa for Fig. 1 (j).

4. Summary

The penning gauge spectroscopy systems are installed at the divertor regions at the torus inner ports with and without the baffle structure. The initial calibration result shows that the partial pressure of helium at the divertor region with the baffle structure is higher than that at the position without the baffle structure by almost one order.

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References

[1] S. Masuzaki, M. Kobayashi *et al.*, Plasma and Fusion Res. **6** (2011) 1202007.

[2] K.H. Finken, *et al.*, Rev. Sci. Instrum. **63** (1992) 1.

[3] T. Denner, K.H. Finken, *et al.*, Rev. Sci. Instrum. **67** (1996) 3515.

[4] M. Lehnen, K.H. Finken, *et al.*, *Proc. 31st EPS Conference on Plasma Phys., London, 2004*, EGA Vol.28G, P-1.138.

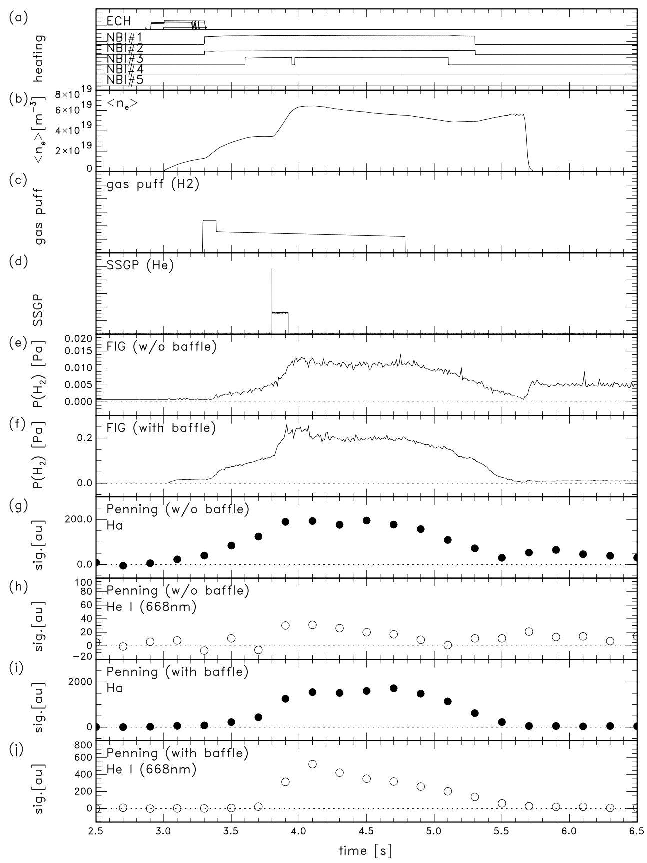

Fig. 1. Temporal evolutions of some parameters and signals in a plasma where helium gas was injected. (a) ECH and NBI heating pulses, (b) averaged electron density, (c) hydrogen gas-puff, (d) helium super-sonic gas-puff, (e) neutral pressure measured by the fast ion gauge at the divertor region w/o baffle structure, (f) neutral pressure measured by the fast ion gauge at the divertor region with baffle structure, (g) H_α intensity in the penning gauge w/o baffle structured divertor, (h) He I (668nm) intensity in the penning gauge w/o baffle structured divertor, (i) H_α intensity in the penning gauge with baffle structured divertor, and (j) He I (668nm) intensity in the penning gauge with baffle structured divertor.