§32. Helium Pressure Measurement by the Penning Gauge Spectroscopy in the Divertor Region

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The compression ratio of helium at the divertor region is important for the helium exhaust in a fusion reactor. Two of ten torus inboard side divertors have the baffle structure on the Large Helical Device (LHD) [1]. In order to evaluate the helium compression ratio at the divertor regions 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]. 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.

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 measurement, 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.

Figure 1 shows an example of temporal evolutions of some parameters and signals in a plasma where helium gas was injected: (a) averaged electron density, (b) hydrogen gas-puff, (c) helium gas-puff, (d) H-pressure without the baffle structure, (e) He-pressure without the baffle structure, (f) H-pressure with the baffle structure, and (g) He-pressure with the baffle structure. The helium gas was injected by the gas-puff at $t = 3.8$ s during the hydrogen gas puff (Fig. 1 (b, c)). One penning gauge spectroscopy system is located at the baffle structured divertor and the other is located at the divertor region without the baffle structure. The hydrogen and helium partial pressures (Fig.1 (d) $\sim$ (g)) are derived from the H_α and He I (668nm) line intensity in the penning gauges, respectively, with the calibration where hydrogen or helium gas was filled in the vacuum vessel. Both H- and He-pressures at the baffle structured divertor are higher than those at the position without the baffle structure by about one order.

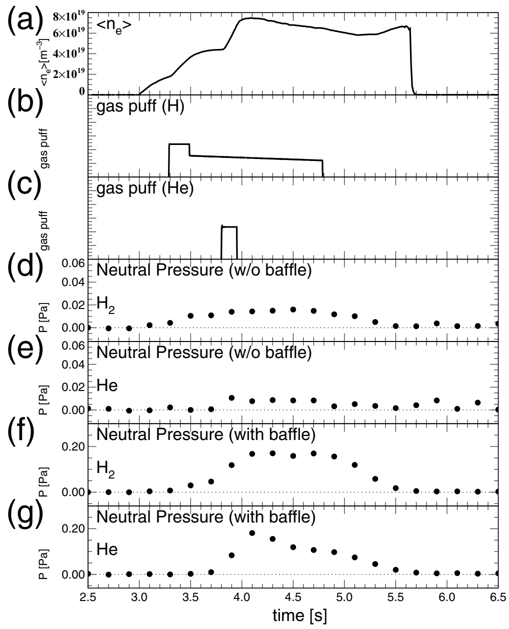

Fig. 1. Temporal evolutions of some parameters and signals in a plasma where helium gas was injected.
(a) averaged electron density, (b) hydrogen gas-puff, (c) helium gas-puff, (d) H-pressure without the baffle structure, (e) He-pressure without the baffle structure, (f) H-pressure with the baffle structure, and (g) He-pressure with the baffle structure.

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