7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

High neutral particle pressure in the divertor section by low temperature mode in LHD

G. Motojima[1, 2], U. Wenzel[3], M. Kobayashi[1, 2], M. Goto[1, 2], Y. Hayashi[1, 2], S. Masuzaki[1, 2], G. Kawamura[1, 2], B. Jagielski[3] and V. Haak[3]

[1] National Institute for Fusion Science (NIFS), [2] SOKENDAI (The Graduate University for Advanced Studies), [3] Max Planck Institute for Plasma Physics

e-mail (speaker): motojima.gen@nifs.ac.jp

In the LHD (Large Helical Device) helical divertor, extremely high neutral particle pressure has been observed at a specific magnetic configuration [1]. A pressure up to a maximum of 1.4 Pa has been achieved, which is equivalent to the pressure achieved in the poloidal divertor in tokamaks. This high neutral particle pressure is considered to be a result of very low temperature within the divertor plasma with low temperature from the various measurements and shows strong dependence on the magnetic configuration. Divertor detachment is crucial for reducing the thermal load in the divertor, but it also leads to a decrease in particle flux to the divertor. Maintaining high neutral pressure within the divertor during detachment is important for efficient particle exhaust, and this study indicates the potential of achieving high neutral particle pressure during detachment using the helical divertor.

Figure 1 shows the variation of the neutral particle pressure with different magnetic configurations along with typical plasma parameters. In these shots the plasma density was ramped up to about 15 × 19 m^{-3}. The plasma was heated with tangential and perpendicular neutral beams (traces a and f). In both plasmas an energy of about 800 kJ was stored, decreasing toward the end of the shot due to the high density at constant heating power. Fig. 1 shows also the sub-divertor pressures and the ion saturation currents of the Langmuir probes. The sub-divertor pressures were measured by fast ionization gauges which enable the direct measurement in the sub-divertor [2], one located in the 6I section and another one in the 8I section (for the geometry of the set-up see Fig. 2 in [2]). The letter "I" stands for inboard side and the number stands for the toroidal position in the LHD. The ion saturation currents were measured with two probe arrays mounted in the target plates in section 8I. Fig. 1(e) and (j) show the sums over the left array, the sums over the right array, and the total ion saturation current giving an approximate measure of the particle fluxes to the targets.

In LHD, different magnetic configurations can be achieved by shifting the magnetic axis position (R_{ax}), which was found to influence the particle flux distribution [3]. The study demonstrated that the high neutral particle pressure in the divertor section was achieved at a relatively inner magnetic axis position of R_{ax} = 3.55 m, corresponding to a pressure approximately five times higher than in the magnetic configuration with the magnetic axis shifted 5 cm outward (R_{ax} = 3.60 m). Measurements such as divertor spectroscopy were conducted to investigate the cause of the high neutral particle pressure in the divertor section, leading to the estimation of temperatures around the divertor section at R_{ax} = 3.55 m in the range of 0.25-0.42 eV, indicating a temperature range in that volume recombination occurs. In this presentation, we will further discuss the mechanism behind the observed high neutral pressure. The data supporting the findings of this study are available in the LHD experiment data repository at https://doi.org/10.57451/lhd.analyzed-data.

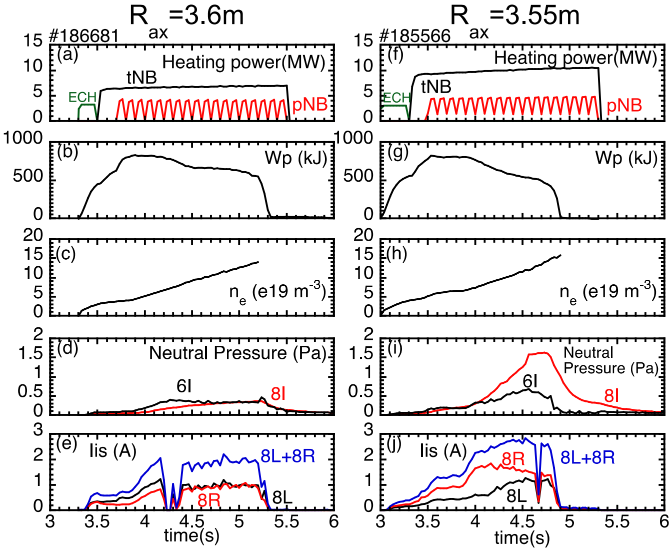

Figure 1: Time traces of two plasma shots with different positions of the magnetic axis: R_{ax} = 3.6 and 3.55 m. (a,f) heating powers, (b,g) stored energy, (c,h) line-averaged densities, (d,i) sub-divertor neutral pressures, and (e,j) ion saturation currents of the target mounted Langmuir probe arrays.

References
[1] U. Wenzel et al., submitted to PRL 2023.
[2] G. Motojima et al.,, Physica Scripta, 97(3):035601, 2022.
[3] T. Morisaki et al.,e Nucl. Fusion 53 063014 (2013).