§21. Analysis of Neutral Density Profile in the LHD Plasma Periphery

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The absolute density profile of neutral particles in the plasma periphery is an essential parameter for investigating particle transport and physical mechanisms of plasma confinement. A H_α emission detector array is installed in an outer port (1-O) for getting information of neutral particle behavior in the LHD plasma periphery. Ambient neutral pressure in the vacuum vessel also has been monitored with fast ion gauges. The investigation of the consistency between the H_α intensity profile and the neutral pressure is carried out by using a fully three-dimensional neutral particle transport simulation code (EIRENE). It contributes to the detailed analysis of the effect of neutral particle behavior on plasma confinement properties in SDC plasmas and long pulse discharge experiments.

The dedicated experiments for investigating the consistency between the above two measurements were performed in an outward shift magnetic configuration (R_{ax}=3.85m). Figure 1 illustrates a three-dimensional grid model for the neutral particle transport simulation with showing the geometry of the line of sight of the H_α emission detectors. Figure 2 indicates the measurements of the vertical profiles of the H_α intensity (open squares) in the case where the averaged plasma density ($<n_e>$)is 3×10^{19}m^{-3} (a) and 6×10^{19}m^{-3} (b), respectively. The small closed circles express the calculations of the H_α intensity profiles obtained by integrating the calculated H_α emission along the line of sight of the detectors. The calculations of the intensity are normalized so as to be consistent with the measured profiles.

Figure 3 (a) and (b) indicate the calculations of the density profile of neutral hydrogen molecules in the two plasma density cases for R_{ax}=3.85m at the toroidal angles where the LHD plasma is vertically and horizontally elongated (ϕ=18° and 0°). The neutral density (n_{H2}) in the plasma periphery increases with the averaged plasma density. The neutral pressure in the inboard side and the lower side (in black circles) also rise with the plasma density. The neutral pressure in the lower side (P^L) is higher than that in the inboard side (P^I) for the both plasma density. The neutral pressures are 2.2 and 1.5mPa for the low plasma density, and are 4.0 and 3.2mPa for the high plasma density, respectively. The ratio of the calculated neutral pressure in the lower side to that in the inboard side (P^L/P^I) is 1.5 and 1.3 in the two plasma density cases.

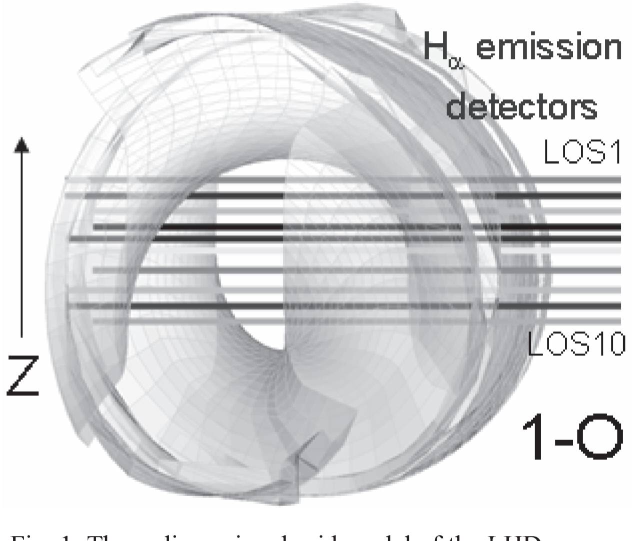

Fig. 1. Three-dimensional grid model of the LHD vacuum vessel for the neutral particle transport simulation.

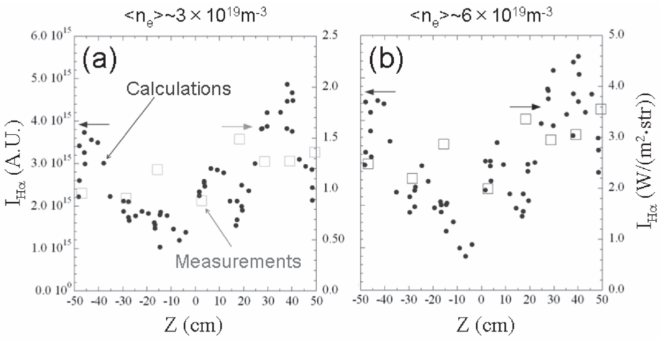

Fig. 2. Measurements of the H_α intensity profiles (open squares), and calculations by the neutral particle transport simulation code (black circles) for the two plasma density cases ($<n_e>\sim3\times10^{19}$m^{-3} (a) and $<n_e>\sim6\times10^{19}$m^{-3} (b)).

The neutral pressure measured with the fast ion gauges installed in the lower (9.5-L) and inboard side (9-I) of the torus was as follows:

$P^{9.5\text{-}L}$=11mPa, $P^{9\text{-}I}$~7mPa in $<n_e>\sim3\times10^{19}$m^{-3},

$P^{9.5\text{-}L}$=29mPa, $P^{9\text{-}I}$~22mPa in $<n_e>\sim6\times10^{19}$m^{-3}.

The ratio ($P^{9.5\text{-}L}/P^{9\text{-}I}$) is 1.6 and 1.3 in the two plasma density cases. The ratio derived from the measurements quite agrees with the calculations. However, the absolute values of the calculated neutral pressure are smaller than the measurements by a factor of about 5. The reason for the discrepancy is likely to be the effect of gas fueling (9.5-L) near the fast ion gauges. Further optimized dedicated experiments are needed for detailed comparison between the two measurements by using gas puffers installed at the position which is far from the fast ion gauges.

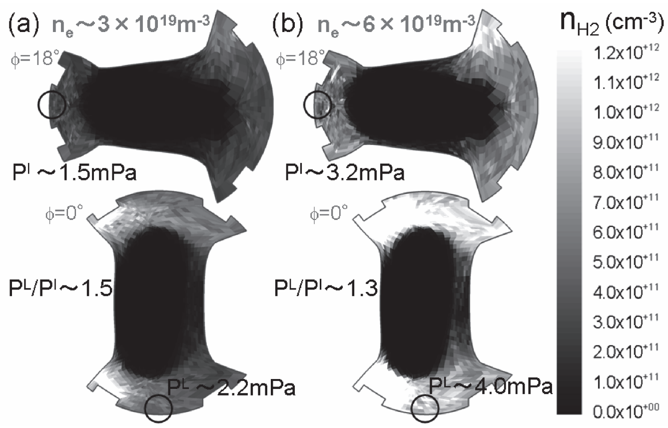

Fig. 3. The calculated density profile of neutral hydrogen molecules for the two plasma density cases ($<n_e>\sim3\times10^{19}$m^{-3} (a) and $<n_e>\sim6\times10^{19}$m^{-3} (b)).