§17. Study on the He Exhaust Characteristics in the Higher Density Regime in HD in LHD

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The ratio of the alpha ash confinement time to the energy confinement time (τ_α^*/τ_E) should be lower than 7 ~ 8 in the high–density (thermally unstable) and low-density (thermally stable) operations in the FFHR helical reactor. Therefore, it is quite important to measure helium particle confinement time experimentally in LHD device from the reactor design point of view. In the previous campaign, the charge exchange recombination spectroscopy (CXS) with positive NBI (40 keV) was used to measure He^{++} ions directly in the low density regime of $1.5\text{x}10^{19}$ m^{-3}. However in the higher density regime, measurement was not possible due to the detector saturation by the strong light in the plasma edge by He gas puffing.

In this fiscal year, CXS has been used up to $5\text{x}10^{19}$ m^{-3} range. Frame just placed at the front of the detector was adjusted and its opening time was narrowed to reduce the total light. He gas puffing experiments have been done in the helical diveror (HD) configuration without active pumping, B_o=2.64T and R_o=3.75. During NBI injection, modulation was applied to the beam to distinguish the H^+ line originated He^{++} ions by charge recombination in the core from the H^+ line in the plasma edge excited by electrons.

In Fig. 1 are shown the CXS signals with/without NBI modulation for He gas puffing, one with NBI modulation but no He gas puffing in the higher density regimes of $4\text{x}10^{19}$ m^{-3}. It is clearly seen that the signal difference between the NBI modulations increases with the time. It means that He ion does not decay and rather increases in HD configuration due to recycling because of no pumping function. However, now we can measure the He ion density in this higher density regime. As LID with pumping function was not used in this fiscal year, the data in this higher-density regime was not added to the database accumulated so far.

In Fig. 2 we summarize the dependencies of the He particle confinement time ratio (τ_α^*/τ_E) on the density, which were measured in the lower density regime. We note that we need data analysis improvement for taking the plume effects into account. At present it is difficult to extrapolate the present data to the higher density regime. Therefore, it is necessary to make the same type experiments in the higher density regime.

In a tokamak, the ratio of the He particle confinement time to the energy confinement time (τ_α^*/τ_E) tends to decrease with the density. Therefore, we believe that τ_α^*/τ_E in LHD would be decreased with density. To confirm it, it is necessary to make experiment in the higher density using LID configuration.

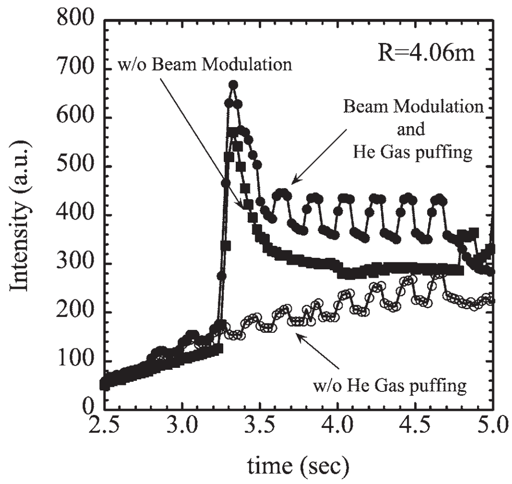

Fig. 1. (a) Modulated signals around 4686 Å on CXS (red: #90136) with He gas puffing, (b) signal with He gas puffing and without NBI#4 (blue: #90139) and (c) without He gas puffing and with NBI #4 (green: #90138).

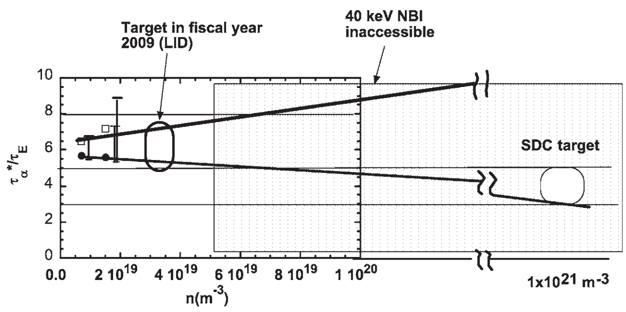

Fig. 2. Measured values of He particle confinement time ratio in the LID configuration vs. the density and its target area in the future SDC reactor operation.

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