§6. Preliminary Study on the He Gas Exhaust in LHD Closed Divertor with Pumping Function

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The ratio of the alpha ash confinement time to the energy confinement time (τ_α^*/τ_E) is one of important parameters in designing the FFHR helical reactor. To study the alpha ash confinement time, He exhaust experiments have been performed using the charge recombination spectroscopy method. As it is difficult to evaluate its value accurately due to complicated observation geometry in the LHD CXS system and He ion plume, we are applying the Fonck model to LHD geometry. In this annul report the signal to noise ratio calculated by the prompt CX signal by NBI and the He ion plume which is the toroidaly drifted He ion created by the NBI injection in both the toroidal directions.

Signal to Noise from the drifted He ion plume created by NBI

We assume He^{++} ion density with the Bi-Fermi profiles injected by gas puffing as shown in Fig. 1. It has double peaks to simulate the skin effect of injected He ions.

For the peak electron density of 0.5x10^{19} m^{-3} with α_n=0.6, the toriodally drifted He^+ ion plume distributions using the Fonck model is shown in Fig. 2. He^+ ions created by CX with NBI drift quickly to toroidal directions with the thermal velocity of He, which is very fast due to the light mass. Ionization rate determines toroidal distribution.

Fig. 3 shows the light emission profiles from the He^+ ion plume due to electron impact excitation. Here newly calculated electron impact excitation rate is used for calculation with the multiplication of the factor 10 taking the uncertainty of the worst case of ℓ-mixing effects. Here, the electron impact excitation rate is comparable to ionization rate, and CX recombination by NBI is one order larger.

In the low-density regime of 0.5x10^{12} m^{-3} (Fig. 4) NBI penetration is good, therefore CX signals come from the inboard and outboard sides. As the prompt signal from NBI and ion plume noise are shown in the same figure, He ion plume signals may not an obstacle in this low-density regime. For given various parameters, simple signal to noise ratio is given by

$$\frac{S}{N} = \frac{n_Z n_{NBI}\langle\sigma V\rangle_{CX}\Delta L}{\int n_e n_{Z-1}\langle\sigma V\rangle_{ex}\,dy} = \frac{1\times10^{18}\times3.3\times10^{14}\times1.2\times10^{-14}\Delta L}{0.5\times10^{19}\times0.18\times10^{14}\times2\times10^{-15}\Delta y}$$

$$\sim\frac{3.96\times0.8}{0.18\times3} = 5.86$$

S/N ratio decreases with the electron density.

In this fiscal year, He gas puff experiments have been performed using the 2008 experimental parameters. Although plasma is shifted at inboard side, different from outboard side position in 2008, similar experimental results have been obtained.

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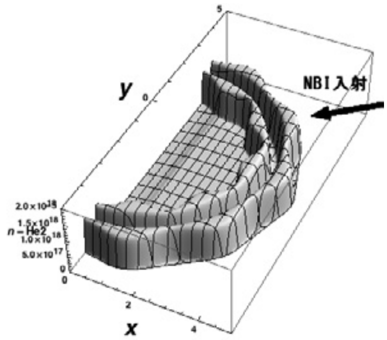

Fig. 1. Assumed He^{++} ion distribution by gas puffing in LHD 3D view.

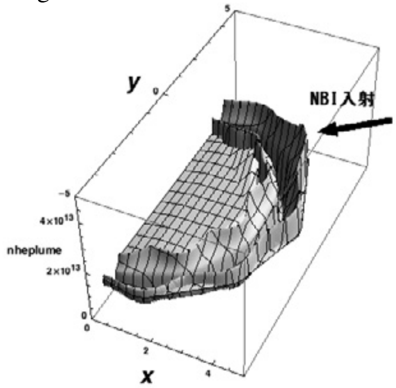

Fig. 2. He^+ ion plume distribution to the toroidal direction.

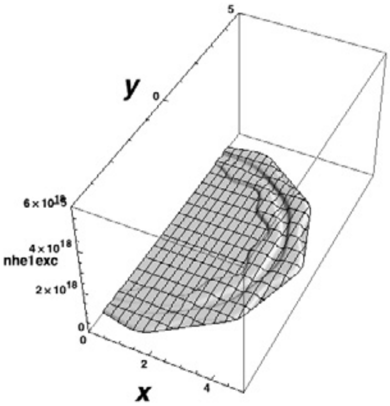

Fig. 3. Noise signal excited by electron impact from He^+ plume ion.

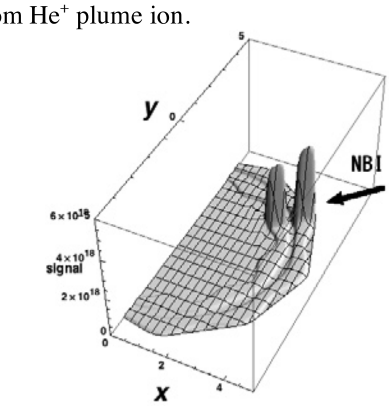

Fig. 4. Signal (two peaks) from He^+ ions excited by NBI and noise from He^+ plume ions.