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LHDにおけるHeガス排気実験
He gas exhaust experiments in LHD

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1.Introduction

The ratio of the alpha ash confinement time to the energy confinement time ($\tau_\alpha*/\tau_E$) 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 (CXS) system. However, it was not certain whether we can interpret the experimental data directly because of complicated observation geometry in the LHD CXS system and He ion plume, which is the toroidaly drifted to both directions of the NBI injection part. Here we applied the Fonk model to LHD geometry with wavy magnetic field lines [Fig.1] and consider the data analysis method. Based on this result we analyze the past data on He gas exhaust experiments in LHD and estimate the He confinement time.

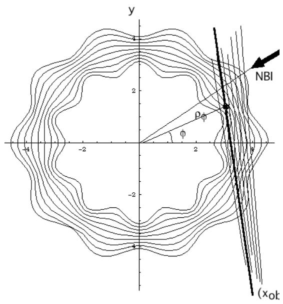

Fig. 1. 2D magnetic field line on the equatorial plane and the observing lines of the CXS in the LHD.

2. Signal to Noise from the drifted He ion plume
2.1. 2D geometry effect

We assume He^{++} ion density with the Bi-Fermi profile which is the double peaks to simulate the skin effect of injected He ions as shown in Fig.2. For the peak electron density of $1x10^{19}$ m^{-3} with profile factor α_n=0.6, He^+ ions created by CX with NBI and the toroidally drifted He^+ ion plume distributions is shown in Fig. 3 using the Fonk model [1]. The He^+ ion plume is produced by electron impact excitation. Here electron impact excitation rate is multiplied by the factor 5 to take into the ℓ-mixing effect based on the recent ADAS data base. The He ion plume starts from the NBI injection part. However, it is smaller than that in previous studies [1].

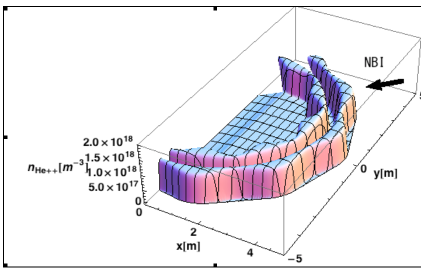

Fig. 2. Assumed He^{++} ion distribution by gas puffing in LHD.

Integrated signal profile along the sight line is shown in Fig.4. On the straight observation line, He ion plume should come in and out due to the wavy field line. However its effect is small and could be neglected in this density regime.

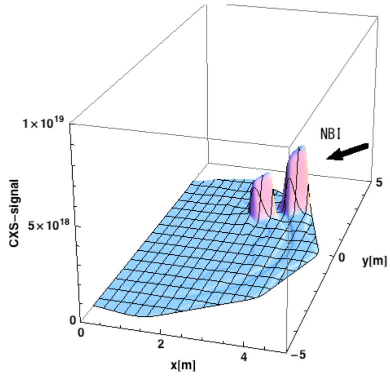

Fig. 3. Signal (two peaks) from He^+ ions excited by NBI and drifted He^+ plume ions.

2.2. 3D geometry effect

In actual situation, the magnetic field line is twisting. Therefore, 2D geometry is overestimating the plume effect. We may be able to interpret the data as it is in this density regime.

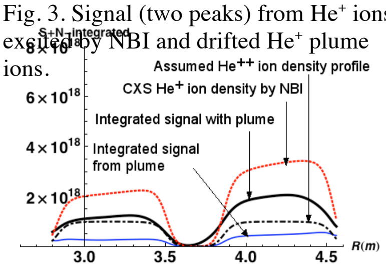

Fig.4. Integrated signal with He^+ plume along the viewing line for n(0)=1.0x10^{19} m^{-3} and T_e(0)=1.5 keV.

3. He exhaust experiments in Local Island Divertor (LID)

In the line averaged density regime of 0.7x10^{19} m^{-3}, He gas puffing into H plasma at 1.5 s with LID configuration has been done using H-NBI modulation. Even when NBI is not applied, He^+ line (4686 Å) has been observed from the low temperature plasma edge on the sight line by He gas puffing. Therefore, NBI modulation is necessary to obtain He^{++} ion density in the plasma and NBI injection part. After subtracting this base signal, He^{++} ion density decay is obtained as shown in Fig. 5. By using the particle balance equation and fitting technique, τ_{He}~ 450ms is obtained without source term. As the energy confinement time is estimated as τ_E=60~85 ms, $\tau_\alpha*/\tau_E$=5.3~7.5 has been obtained.

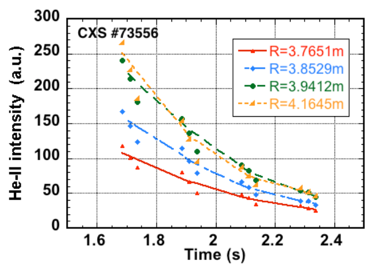

Fig. 5 He^{++} decay as a function of time in LID experiment (#73556)

[1] R.J.Fonk, D.S.Darrow and K.P.Jaehnig, Physical Review A, 29 (1984) 3288