§8. He Gas Exhaust Experiments in LHD Closed Divertor with Pumping Function and Resonance Magnetic Perturbation Coils

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i) Introduction

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 conducted 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 have applied the Fonck model to LHD geometry. When the signals obtained by the prompt CX signal by NBI and the He ion plume are integrated along the tangential sight line, it is found that the measured profile does not depends on the wavy magnetic field line in LHD, as concerned in an earlier phase. We also made a preliminary experiment of the effect of the resonant magnetic field perturbation on the He exhaust.

ii) Integrated signal including noise from the drifted He ion plume

In Fig. 1 are shown the assumed He^{++} ion distribution (black dotted line) injected by gas puffing, charge exchanged He^{+} ion by NBI (red dashed line), integrated signal and noise along the viewing line (black solid line), integrated plume noise along the viewing line (blue solid line) for n(0)=0.5x10^{19} m^{-3}. As NBI penetration is good, CX signals come from the inboard and outboard sides. The toroidally drifted He^{+} ion plume distributions, based on the Fonck model, are integrated with signal along the tangential viewing line. The assumed He^{++} ion distribution and integrated signal and noise along the viewing line show the same profile except for the central area. Therefore, their signals are not affected by the wavy 2D helical field as concerned in the initial phase. In this calculation, ℓ-mixing effect on the electron excitation of the he plume is taken as one order larger.

Calculated results for higher density n(0)=2x10^{19} m^{-3} and n(0)=4.0x10^{19} m^{-3} are shown in Fig.2 and 3. It is shown that the assumed He^{++} ion distribution and integrated signal and noise along the viewing line show almost the same. It is also getting known that from ADAS data, ℓ-mixing effects on the He plume are found to be smaller than the previously thought. If both He $^{++}$ and H^{+} ions are interpreted as a measure for He ash, He plume is no more noise, and its interpretation is much simpler.

iii) RMP application experiments

In the present LHD the pumping function is weak because all the pumping systems are not installed yet. If the pumping alone is not enough for He exhaust in the future reactor, some method to enhance the He ash exhaust should be considered. One of candidate is the internal means to disturb the particle confinement inside the plasma.

The resonant magnetic field perturbation is applied whether it can help or not the He exhaust. In this fiscal year, m/n=1/1 was applied. As shown in Fig. 4, at the observation point of R= 3.879 m, He CX signal is slightly decreasing compared to no m/n=1/1 case.

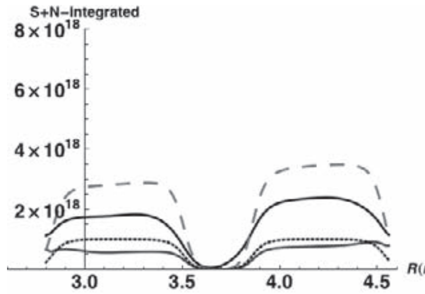

Fig.1. Black dotted line: assumed He^{++} ion distribution, Red dashed line: charge exchanged He^{+} ion by NBI, Black solid line: integrated signal and noise along the viewing line, Blue solid line: integrated plume noise along the viewing line for n(0)=0.5x10^{19} m^{-3}.

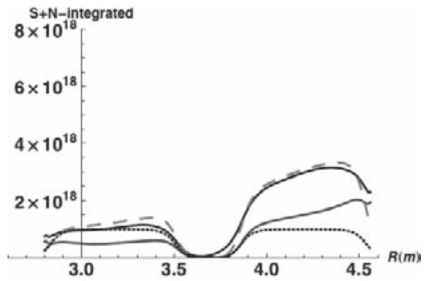

Fig.2. The same as in Fig.1 except for n(0)=2x10^{19} m^{-3}

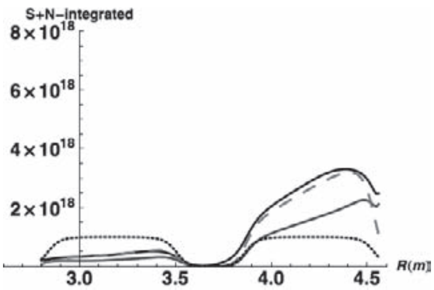

Fig.3. The same as in Fig.1 except for n(0)=4.0x10^{19} m^{-3}

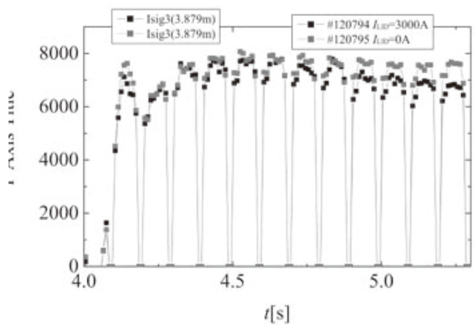

Fig.4 Comparison of the measured CX signals from He^{++} ion during the He gas puff and RMP application.

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