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Characterization of Isotope Effect on Particle Transport in Large Helical Device

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Particle transport in magnetically confined plasmas has been investigated on Large Helical Device (LHD). This study aims at characterization of isotope effect on particle transport.

The most promising fusion reaction for a fusion reactor is the reaction of deuterium (D) and tritium (T). Both deuterium and tritium are isotopes of hydrogen, and the control of their concentration of 50/50 is required to maximize fusion power output. Nonetheless, difference and similarity of particle transport of these isotopes have not been identified experimentally yet.

Recently, deuterium plasma experiment has begun in LHD, and measurement separating hydrogen (H) and deuterium (D) density profiles has become available by bulk charge exchange recombination spectroscopy (b-CXRS) [1]. Global particle confinement time in steady state as well as transient decay time after pellet injection have been analyzed for H, D and H/D mixture plasmas in order to characterize the isotope effect on particle transport.

In steady state, the global particle confinement time τ_p is obtained by the following relation between the flux of particles flowing into the plasma n_{inflow} and the plasma electron density $\overline{n_e}$ [2]. The index as a measure of τ_p in an arbitrary unit is defined by

$$\tau_p = \frac{\overline{n_e}}{n_{inflow}}$$

Here, n_{inflow} is evaluated by the following equation using the emission line intensities of H_α, D_α and HeI.

$$n_{inflow} \propto (I_{\mathrm{H}\alpha} + I_{\mathrm{D}\alpha} + 2I_{\mathrm{HeI}})$$

Then statistical regression analysis of dataset ranging $B = 1.4\mathrm{T}$ or $2.4\mathrm{T}$, $0.87\mathrm{MW} < P < 12.5\mathrm{MW}$, $1.0 \times 10^{19}\mathrm{m}^{-3} < \overline{n_e} < 5.7 \times 10^{19}\mathrm{m}^{-3}$ has been conducted in terms of the averaged particle mass number of plasma m, the magnetic field B, the plasma electron density $\overline{n_e}$, and the absorbed heating power by NBI or ECH P. It has been found, in particular, that the global particle confinement time deteriorates from H to D.

The transient decay time of H/D concentration after H or D pellet injection has been also analyzed.

Figure 1 shows (a) temporal evolution of $\overline{n_e}$ and (b) concentration of H ions in the peripheral region which is measured by b-CXRS when a H pellet was injected into D dominant plasma. It shows sudden increase in the concentration of H and $\overline{n_e}$ at 4.46s by H pellet injection.

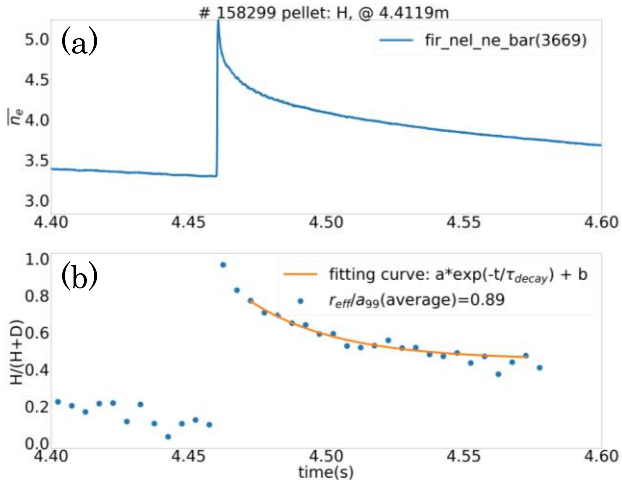

Fig.1 The temporal evolution with pellet injection. (a) Line averaged electron density in the vicinity of the center chord. (b) Concentration of H ions in the peripheral region measured by b-CXRS.

The concentration of H decreases exponentially after pellet injection. This decay time τ_{decay} has been surveyed for cases with H and D pellet injection into target plasmas with different degree of H/D mixture and then the accumulated data is discussed by the statistical regression analysis in the same manner as the global particle confinement time in steady state. Provisional analysis suggests no significant difference in the decay time between H and D particles in contrast to the result from the global particle confinement time.

Difference and similarity of these observations in steady-state and transient response is discussed in detail by parameter dependence.

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References

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