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ヘリオトロンJにおける水素同位体効果解明を目指した密度変調実験
Density modulation experiment for clarification of Hydrogen isotope effects in Heliotron J

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Understanding the isotope effects on transport is one of the important issues to predict the performance of future DT fusion reactor. In Heliotron J, we studied the isotope effects between hydrogen and deuterium plasma on particle transport of ECH heated plasma. The experiment was performed for the line-averaged density 0.6 × 10^{19} m^{-3} with 252 kW 70GHz second harmonic heating with $|B| \approx 1.3$ T. The fueling ratio, which was defined as $n_H/(n_H+n_D)$, was approximately 10 % in the deuterium plasma and 80 % in the hydrogen plasma.

The different decay time of the line-averaged density after turning off the external gas fueling was found. The decay time is 12.8 ms and 15.9 ms for the hydrogen plasma and the deuterium plasma, respectively. The longer decay time in the deuterium plasma suggests better particle confinement than in the hydrogen plasma. However, the different wall recycling can cause the different decay time as well.

Therefore, in order to investigate difference of the particle transport without recycling effects, density modulation experiments were performed. From the density modulation experiments, the diffusion coefficient (D_{mod}) and convection velocity (V_{mod}) are estimated separately. Also, difference of the particle source rate does not affect the estimation of D_{mod} and V_{mod} [1]. Particle balance equation of the modulation components are solved. Then, the optimized D_{mod} and V_{mod} are estimated. The estimated D_{mod} and V_{mod} account for the experimental observed modulation amplitude and phase [2].

Two channels of interferometer were used. One is a microwave interferometer at $\rho = 0.05$ and the other is FIR interferometer at $\rho = 0.35$ [3]. Three different modulation frequencies (50, 100 and 125 Hz) were used in order to increase the constraint to estimate D_{mod} and V_{mod}.

Figure 1 shows phase difference and modulation amplitude ratio between the line-averaged densities from two channels. In the case of 50 Hz, both the modulation amplitude ratio and the phase difference in the deuterium plasma were clearly higher than those in the hydrogen plasma. Figure 2 shows the estimated D_{mod} and V_{mod} using three modulation frequencies. The convection velocities for both plasmas direct to inward and the absolute value for the deuterium plasma is smaller than that for the hydrogen plasma. The diffusion coefficient of the deuterium plasma is smaller than that of the hydrogen plasma. This suggests particle confinement is better in deuterium plasma than in hydrogen plasma.

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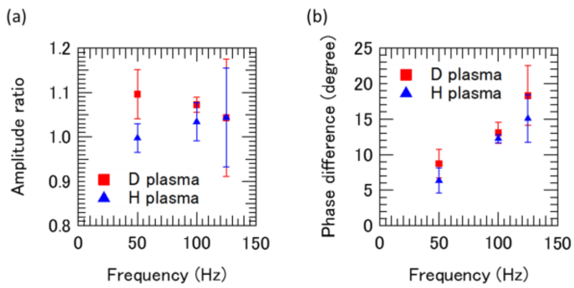

Fig. 1. (a) Amplitude ratio and (b) phase difference calculated from the experiment.

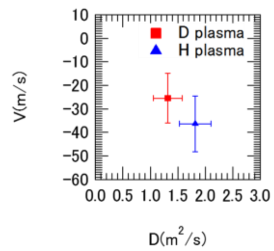

Fig. 2. First result of particle transport for deuterium plasma and hydrogen plasma