§6. Comparison of Heat Transport Properties in Hydrogen and Helium ECRH Plasmas

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Improvement of the confinement with the increasing in the isotope mass is generally observed in tokamaks. While in stellarator, clear mass effects in the confinement are not reported[1]. On the Large Helical Device (LHD), the deuterium discharge experiments are planned to be launched in 2016. Before the deuterium experiments, the heat transport properties in H and He plasmas were compared.

1 MW ECRH applied to H and He plasmas. Plasmas were sustained only by ECRH. Neutral beam was injected to measure the ion temperature profile by a charge exchange spectroscopy system in some experiments. A series of experiments were performed at 0.4×10^{19} m^{-3} < $n_{e,avg}$ < 3.0×10^{19} m^{-3}. No distinct difference in the electron density dependence of the central electron temperature between H and He plasmas is observed, as shown in Fig. 1. While, the central ion temperature measured by a crystal spectrometer observing the Doppler broadening of Ar line is clearly higher for He than that for H in low electron density regime ($n_{e,avg} < 1 \times 10^{19}$ m^{-3}). The difference in the ion temperature reduces with the increasing in the electron density.

The profile of the ion temperature was clearly higher for He than that for H plasmas at $n_{e,avg} \sim 0.5 \times 10^{19}$ m^{-3}, as shown in Fig. 2. The ECRH total power was experimentally evaluated in modulated ECRH experiments, and the shape of radial profile of ECRH deposition was calculated by ray trace code LHDGauss[2]. The heat diffusivity was evaluated by power balance analysis using TRsnap[3] which is a module of TASK3D[4]. We focus on $\rho > 0.4$ in the evaluation of the electron heat diffusivity because the center location of ECRH deposition was experimentally confirmed to be $\rho < 0.4$ by phase analysis of the FFT components of the electron cyclotron emission signals. There is no difference in the electron heat diffusivity at $\rho > 0.4$ for H and He ECRH plasmas. While, the ion heat diffusivity was lower for He than that for H plasmas at $n_{e,avg} \sim 0.5 \times 10^{19}$ m^{-3}.

Figure 3 shows the electron and ion heat diffusivity at $\rho \sim 0.6$ as a function of the normalized collisionality $\nu_h^* \sim Z_{eff}\nu_{ei} qR/(\varepsilon_{h,eff}^{1.5} V_{Te})$ [5]. There is no significant difference in the electron heat diffusivity between H and He ECRH plasmas. The ion heat diffusivity is lower in He plasmas than in H plasmas in low collisionality regime where $\nu_h^* < 1$. These results are useful for clarification of the mass and charge effects on the confinement.

1) U. Stroth, Plasma Phys. Controlled Fusion **40**, (1998) 9.
2) Shin, K. *et al*., AIP Conf. Proc. **669**, (2003) 187.
3) Seki, R. *et al*., Plasma Fusion Res. **6**, (2011) 2402081.
4) Yokoyama, M. *et al*., Plasma Fusion Res. **8** (2013) 2403016.
5) Murakami, S., Nucl. Fusion **42** (2002) L19–L22.

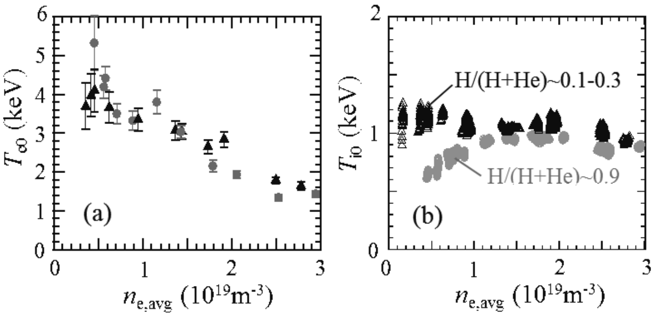

Fig. 1. Electron density dependences of central (a) electron and (b) ion temperature in H dominate plasmas (gray) and He dominant plasmas (black).

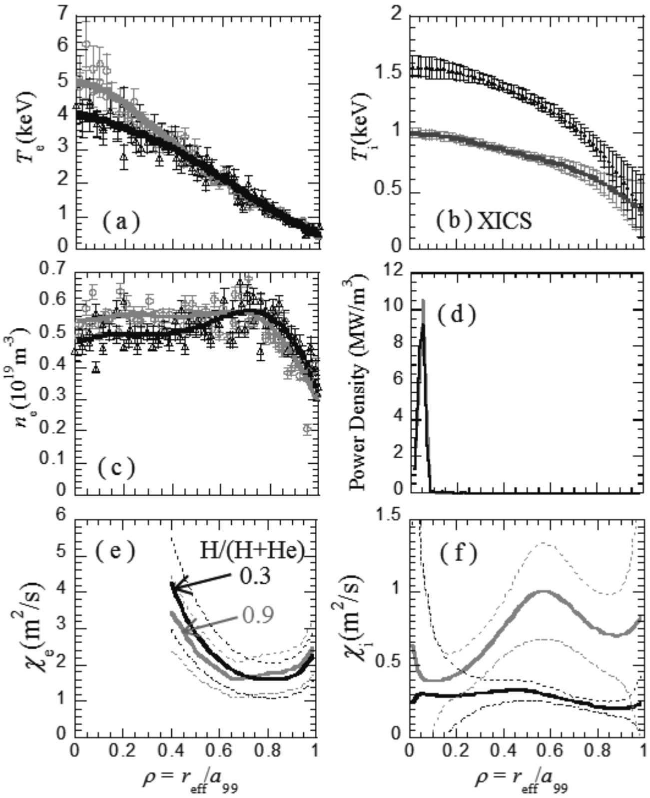

Fig. 2. Profiles of (a) electron and (b) ion temperature, (c) electron density, (d) heating power density, (e) electron and (f) ion heat diffusion coefficient in H (gray) and He (black) plasmas.

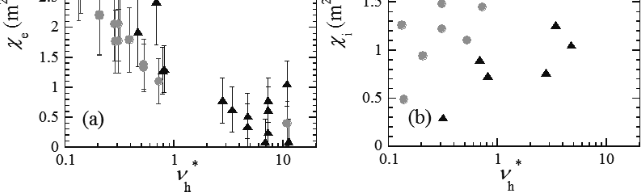

Fig. 3. Dependences of (a) Electron and (b) ion heat diffusion coefficient in normalized effective collisionality ν_h^* for H (gray) and He (black) plasmas.