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Isotope effects on transport and turbulence in ECRH plasma of LHD

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The transport of different hydrogen isotopes is an important issue for predicting the performance of ITER and the future reactor operation. In a tokamak, improved transport character and lower H mode threshold power in D plasma than in H plasma were reported. Both tokamak scaling (ITER98y2) and helical scaling (ISS04) follow gyro-Bohm (GB) scaling with the exception of ion mass and ion charge number. While GB scaling predicts enhanced transport in D plasma, many experiments show better confinement in D plasma. In this paper, we report the first results of the improved confinement due to the isotope effects in ECRH plasma of LHD.

Figure 1 shows comparison of predicted τ_E by ISS04 scaling and experimental τ_E. The enhancement factors are τ_E / $\tau_{E\ ISS04}$=1.27+-0.12 in D plasma and 1.09+-0.02 in H plasma. Thus, improvement of τ_E in D to H is 17%. In the dataset, the contamination of helium is less than 5% and the purity of the H and D are higher than 80%, respectively. The regression analysis was performed, then, the scaling $\tau_{E\ ECH} \propto A^{0.24\pm0.01} n_{e\ bar}^{0.58\pm0.01} P_{abs}^{-0.52\pm0.01}$were obtained, where A is ion mass (1 for H, 2 for D), $n_{e\ bar}$ is the line averaged density, and P_{abs} is absorption power. The power exponent of A, which is 0.24, is similar value to tokamak L mode scaling.

Figure 2 shows comparison of profiles for almost identical $n_{e\ bar}$ and P_{abs} in H and D plasma. As shown in Fig.2 (a), n_e profiles are clearly different. In D plasma, n_e profile is clearly hollow, while it is flat in H plasma. Since neutral penetration of H and D are almost identical, the difference of n_e profile is due to the difference of transport. T_e is clearly higher in D plasma at r_{eff}/a_{99}<1.0, while ECH power deposition profiles are almost identical. In H plasma, logarithmic gradient (L_{Te}^{-1}) of T_e is constant at r_{eff}/a_{99}=0.2~0.9, while in D plasma, L_{Te}^{-1} varies depending on the location. Stronger stiffness is found in H plasma. Figure 2 (d) shows comparison of ion scale ($k\rho_i$~0.2) turbulence level measured by two dimensional phase contrast imaging [1]. The edge turbulence level at r_{eff}/a_{99}>0.9 are almost identical both in H and D plasma, while, core turbulence level at r_{eff}/a_{99}<0.9 in H plasma is clearly higher than those in D plasma. Trapped electron mode (TEM) and ion temperature gradient mode (ITG) are possible candidates of measured turbulence. Recent gyrokinetic analysis indicates stronger collisionality stabilization of TEM in D plasma and stabilization effect due to hollowed profile for TEM and ITG [2,3]. These two analysis results account for the observation qualitatively. The difference of stiffness and turbulence characteristics in H and D plasma are observed. This is clear contrast to the tokamak ECRH L mode plasma, where gyrokinetic analysis showed common characteristics both in H and D plasma [4].

References

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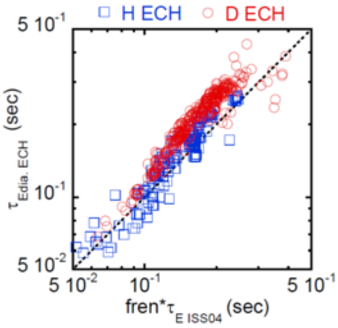

Fig.1 $\tau_{E\ exp.}$ and $\tau_{E\ ISS04}$

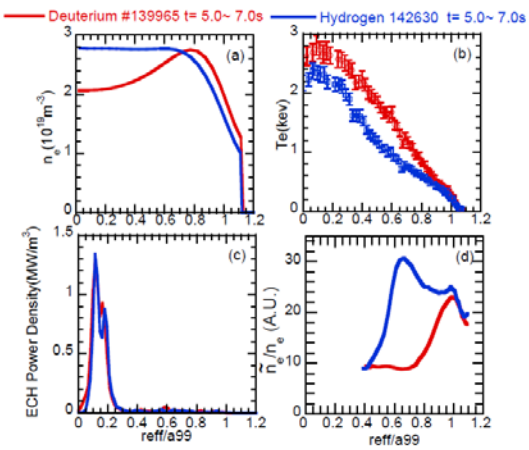

Fig.2 Comparison of profiles in D and H plasmas (a) n_e, (b) T_e, (c) ECH deposition profile and (d) turbulence level