§3. Effect of Rotational Transform on Confinement of ECH Plasmas in LHD

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Extensive efforts to document the characteristics of an energy confinement time have been made under the international collaboration for inter-machine comparison. They have revealed that robust dependence on operational parameters commonly exists, which enables a scaling expression of energy confinement time [1];

$$\tau_E^{ISS04} = 0.134 a^{2.28} R^{0.64} P^{-0.61} \bar{n}_e^{0.54} B^{0.84} \iota_{2/3}^{0.41} \quad .$$

Nonetheless, it should be noted that dependence on the rotational transport still contains uncertainties. There is co-linearity between the rotational transform ι and the aspect ratio in a heliotron line (LHD, CHS, Heliotron E and ATF). The fine structure of the ι dependence due to low-order rationals is a salient feature in W7-AS. Although individual experimental observations as well as the plasma current dependence in tokamaks suggest the existence of positive dependence of the energy confinement time on ι, the variation of the data indicates possible uncertainties.

Flexibility of the magnetic configuration in LHD together with the limiter insertion enables the experiment to clarify the effect of ι on confinement. The helical coil of LHD consists of 3 blocks and the aspect ratio can be controlled by adjusting the current of each block. Also the head of the Local Island Divertor can be used for an efficient limiter. Combination of these tools realizes the exactly the same aspect ratio, i.e., the same minor/major radii with different ι by 70 % (see Fig.1).

The global energy confinement time and local transport in the plasmas with the centrally focused ECH of 180-700kW at B=1.5T have been investigated for these two configurations. The density has ranged between 0.25 - 1.5×10^{19}m^{-3}.

Figure 2 shows the extracted ι dependence with assumption that the other parameter dependences can be described by the ISS04;

$$\tau_E^{\exp} / \tau_E^{ISS\_WOiota} = \tau_E^{\exp} / 0.134 a^{2.28} R^{0.64} P^{-0.61} \bar{n}_e^{0.54} B^{0.84} .$$

Here it should be noted that a, R and B are fixed in the present study. The significant dependence of $\tau_E \propto \iota^{0.57}$ has been found.

The central electron temperature increases by 20-30% for the plasmas with the same electron density and ECH power and higher ι. Figure 3 shows the profiles of the ratio of the electron heat diffusivity and ι. The electron heat transport is improved by the increase of ι. It is also found that this trend is distinguished towards the edge. This dependence can be described by the relation of $\chi_e \propto \iota^{-0.5}$, which is consistent with the trend of the energy confinement.

[1] H.Yamada et al., Nucl. Fusion **45**, 1684 (2005)

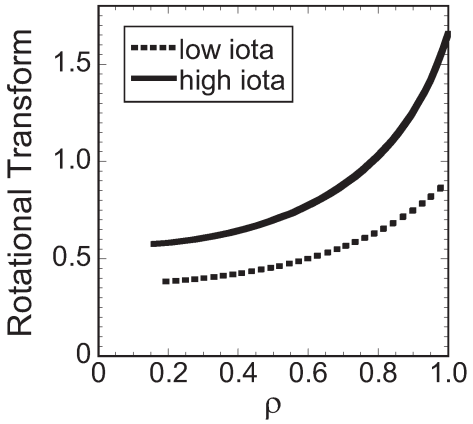

Fig.1 Rotational transform profiles for the cases with the same R_{ax}/a=3.6m/0.52m. The values of ι_0 and ι_a are 0.38/0.57 and 0.94/1.61 for the cases with higher ι (solid curve) and lower ι (dotted curve), respectively.

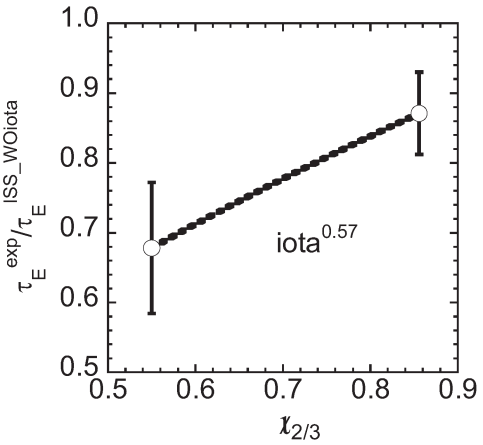

Fig.2 Dependence of energy confinement time normalized by the scaling expression with exclusion of ι dependence on ι at ρ=2/3.

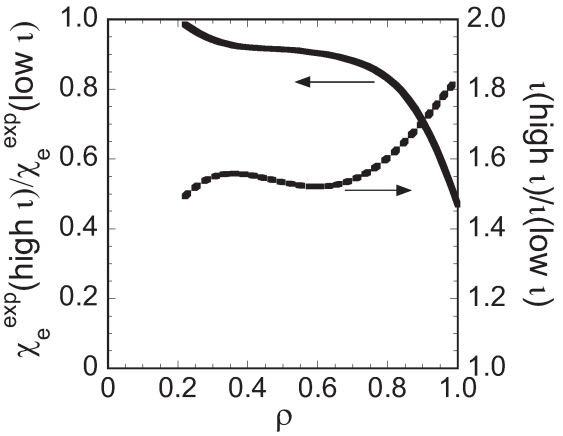

Fig.3 Profiles of the ratios of electron thermal diffusivity (solid curve) and rotational transform (dotted curve).