§27. Condition Study of Edge Transport Barrier Formation with Comparison between CHS and Heliotron J

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The edge transport barrier (ETB) like the tokamak H-mode phenomena have been observed in both Heliotron J and CHS devices. The purpose of the study is understanding of the common physics for the improved transport phenomena of the helical plasma. In CHS device, the power threshold of the ETB formation depends on the magnetic structure of the helical plasma, which can be modified by the shift of the magnetic axis location. The ETB formation in the CHS experiments has been observed in the axis location of 88.1cm - 94.5cm. When the magnetic axis moves to the inward direction from the standard location (R_{ax}=92.1 cm) , the threshold power increases. When the magnetic axis moves to the outer direction, the threshold power decreases to above 96cm, and the ETB formation has not been observed from 97cm. We have hypothesis that these phenomena relate to the rotational transform. The free boundary VMEC calculation result shows that no rational surface of the $\iota = 1$ in the magnetic configuration of the R_{ax}=88.1cm. This result have accordance with no ETB of the inward shift configuration. However, this does not explain the decrease of the threshold power for the formation of the ETB in the outward shift configuration.

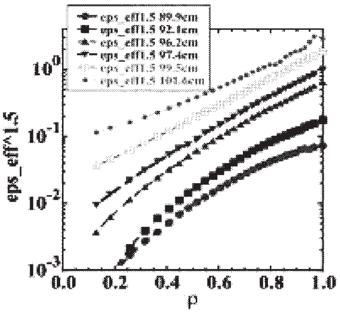

Fig. 1: Effective ripple as a function of a magnetic axis location.

Figure 1 shows the effective ripple of the magnetic axis location of from 89.9cm to 101.6cm. The effective ripple in the edge region is considerably larger than that in the core region. In addition, the value increases with the outward shift of the magnetic axis. When the ETB has not been observed, the effective ripple $\epsilon_{eff}^{1.5}$ is greater than the value of 2×10^{-1}. Figure 2 shows the dependence of the poloidal viscosity on the magnetic axis location. This calculation shows that the poloidal viscosity is also significantly large in the edge region and increases by the outward shift of the magnetic axis. ETB has only observed under the condition of the poloidal viscosity decreases below 0.3. These results suggest that the possibility of the relation between the poloidal viscosity and the ETB formation.

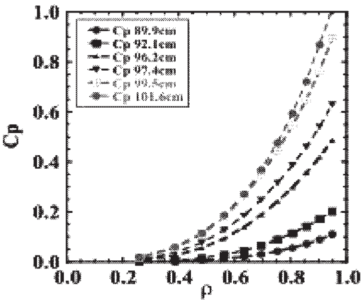

Fig. 2: Poloidal viscosity as a function of a magnetic axis location.

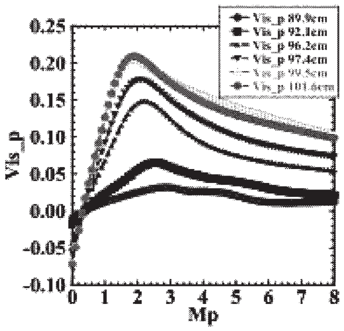

Fig. 3: Poloidal viscosity as a function of a Mach number.

Figure 3 shows the poloidal viscosity as a function of Mach number. When the poloidal viscosity increases with the Mach number, and the viscosity reaches at peak value around $M_p = 2$. The poloidal viscosity monotonically decreases from the peak value in $M_p > 2$. The value of the poloidal viscosity in the inward shift configuration is also smaller than that in the outward shift location. In addition, the variation of the poloidal viscosity value is almost flat in the inward shift configuration. Therefore, in the outward shift configuration, the poloidal flow is small due to the larger viscosity, and the more power is required to overcome the peak of the poloidal viscosity. However, in the inward shift configuration, the poloidal flow is easily produced because of the low and small variation of the viscosity. These result suggest the possibility that the threshold power variation on the magnetic axis shift relates to the production of the poloidal flow.

In future, we have a plan that the same experiment and calculation as the above mentioned will be performed on Heliotron J . The comparison of the threshold power, the rotational transform dependence, the poloidal viscosity, the effective ripple, and the poloidal flow will provide the common understanding of the ETB physics of the helical plasma.