§20. Dependence of Poloidal Viscosity on Magnetic Configuration in Heliotron J and its Implication to H-Mode Quality

Yokoyama, M., Suzuki, Y.,
Nakamura, Y., Mizuuchi, T., Sano, F., Heliotron J Experimental Team (Kyoto Univ.)

The dependence of the confinement quality of H-mode on magnetic configuration has been observed in Heliotron J (HJ) based on the rotational transform scan experiment 1). The experimental edge rotational transform dependence of the confinement enhancement factor, $H_{ISS95}(= \tau_E^{exp}/\tau_E^{ISS95})$ over the L-mode confinement has revealed that there exist the specific configurations for which the high quality H-mode ($1.3< H_{ISS95}<1.8$) are attained, where τ_E^{exp} is the experimental global energy confinement time and τ_E^{ISS95} is the confinement time scaling so called ISS95 2) from the international stellarator database.

As an attempt to understand this configuration dependence, the geometrical neoclassical poloidal viscous damping rate coefficient, $C_p = \langle \mathbf{e}_p \bullet \mathbf{B}/B \rangle$, 3) has been estimated. Here, $\boldsymbol{B}$ is the magnetic field vector, $\mathbf{e}_p$ the poloidal base vector in the Hamada coordinates and bracket indicates the flux surface average. VMEC2000 has been utilized to enhance the convergence property of MHD equilibria to feature the corrugated surface shapes, especially close to the plasma periphery, as much accurate as possible since such a corrugated surface might affect the poloidal flow through enhancing the poloidal viscosity. However, it has been rather difficult to reconstruct corrugated surface regions fully even with the VMEC2000, which is the future subject to resolve.

The poloidal viscous damping rate coefficients are plotted in Fig. 1 as a function of plasma radius for the series of four magnetic configurations with different edge rotational transform ranging from 0.493 to 0.64. The H_{ISS95} has been evaluated for these four cases as, H_{ISS95}~1.8 (0.493), 1.4 (0.56), 1 (0.597) and 0.8 (0.64). From the configuration dependence of Cp, there seems to be some coincidence between the H_{ISS95} and the reduction of Cp in the inner region. However, this result still remains inconclusive due to the lack of more comprehensive and accurate equilibrium information such as the magnetic island chain anticipated at the plasma periphery (related to the corrugates flux surfaces as pointed above). The construction of Boozer coordinates by following magnetic field lines (then transformation to Hamada coordinates) is one of candidates to overcome this problem. In addition, more investigation is required to include the dependence of the viscous damping rate on edge pressure and collision time. In order to examine the relevance of such a theoretical analysis, measurements of edge impurity ion poloidal rotation by means of charge-exchange recombination spectroscopy is under preparation.

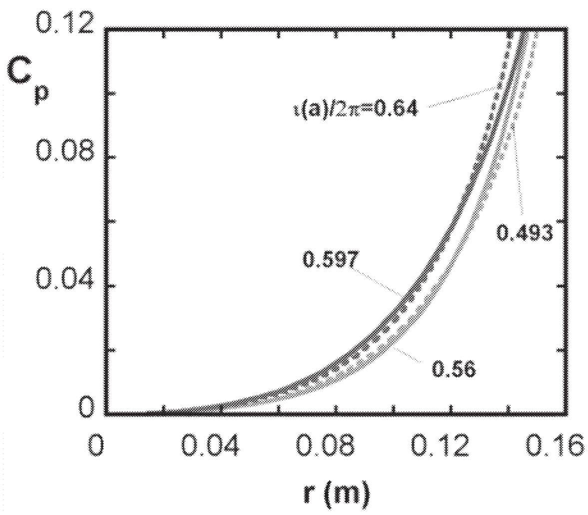

Fig. 1 The radial profile of Cp for four magnetic configurations with different edge rotational transform.

References

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