§17. Theoretical Study and Experimental Verification on the Effects of Magnetic Configuration on the Improved Confinement Mode in Heliotron J

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The inter-relationship between energy confinement and magnetic configuration has been progressed in Heliotron J by utilizing its high degree of the flexibility of magnetic configuration properties.

It has been systematically and clearly demonstrated[1)] that the energy confinement (normalized by ISS04 scaling law) becomes improved as the effective helicity of the configuration becomes smaller (due to the change of the bumpy field component). Considering both the effective helicity is estimated from the neoclassical diffusion coefficient in 1/ν regime (This collaborative subject has primarily contributed to provide its values) and the energy confinement is not governed solely by neoclassical diffusion, this fact found in Heliotron J (as well as magnetic axis scan experiment in LHD[2)]) indicates that the neoclassical optimization works for anomalous (turbulent) transport reduction as well. This has provided the main stream in the Coordinated Working Group Meeting (CWGM) for Confinement Studies in Stellarator/Heliotrons to facilitate the effects of magnetic configuration on plasma confinement in wide range of helical devices worldwide.

By promoting the domestic and international collaborations to extract the comprehensive understanding in helical devices, the 2nd (Jun. 2007) and 3rd (Oct. 2007) CWGM has focused on the effects of the rotational transform/magnetic shear on confinement. Heliotron J and W7-AS (whose typical rotational transform is close to 0.5), and TJ-II and H-1 (rotational transform is above 1) are characterized by low-shear configurations. Firstly, systematic investigation on these low-shear devices was initiated and the interim report was presented at ITC17/ISHW16[3)], where the effects of low-order rational surfaces and also the magnetic shear there are summarized based on experimental observations from these devices. The theoretical study to clarify the effect of existence of rational surfaces on H-mode transition found in Heliotron J[4)] as well as in W7-AS[5)] is also the important issue in this regard to elucidate the common/different feature among different magnetic configurations.

Datasets from high-shear devices such as LHD and CHS have also been substantially accumulated. Especially in LHD, its high flexibility of magnetic configuration has been utilized (such as magnetic axis scan, ellipticity control and the coil-current-center control (for aspect ratio control) etc., and have provided unique inputs to the International Stellarator/Heliotron Confinement database. This addition will also broaden the range of analysis and enhance the physics understanding.

This mutual collaboration with Heliotron J has been the basis to facilitate the domestic and international collaborations in the above mentioned issue and will continue to play this role.

1) F.Sano et al., 20th IAEA Fusion Energy Conference, EX/5-5, Chengdu (2006).
2) H.Yamada et al., Nucl. Fusion 45 (2005) 1684.
3)E.Ascasibar et al., Plasma and Fusion Res. Vol.3 (2008) S1004.
4) F.Sano et al., Nucl. Fusion 45 (2005) 1557.
5) F.Wagner et al., Plasma Phys. Control. Fusion 36 (1994) A61.