§27. Theoretical Study Based on 3D Magnetic Field Structure towards Confinement Improvement in Heliotron J

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The electrode biasing experiments aiming the confinement improvement has been initiated on Heliotron J, after the successful demonstration of confinement improvement on CHS and TU-Heliac[1-3]. In this series of biasing experiments on different helical devices, the impact of the neoclassical poloidal viscosity (affected by the three-dimensionality of magnetic configurations) on the transition criterion has been focused. It should be noted that, in FY2009, the electrode biasing experiment was performed also on LHD[4].

Heliotron J has the characteristic magnetic structure close to so-called "isodynamicity" by the appropriate combination of the bumpy, helicity and toroidicity components of the magnetic field. It is comparatively unique to heliotron and heliac magnetic configurations. Thus, knowledge from bias experiments from Heliotron J will contribute to establish the comprehensive understandings on the impact of the neoclassical poloidal viscosity on confinement improvement in helical (or even on general toroidal) plasmas.

A low magnetic-field-strength (0.0875T) configuration was utilized to perform the trial-experiment. The poloidal viscosity based on Ref.5) was estimated as a function of the poloidal Mach number (Mp) in such a configuration with assumed certain plasma parameters, which reveals there appears a local maximum of the viscosity around Mp~2. This information has been utilized to estimate key parameters such as the required poloidal torque for inducing the poloidal rotation.

Theoretical investigation for normal magnetic field strength configurations has also been performed by utilizing the equilibria for three typical magnetic configurations. Those are "standard", "High-Bumpy" and "Low-Bumpy" configurations. The bumpy field component (with the poloidal mode number of zero, which means that it done not vary in the poloidal direction) does not contribute to the poloidal viscosity. Figure 1 shows the poloidal viscosity (normalized) as a function of Mp on these three configurations, all at ρ=0.45 (electrode was inserted to this minor radius in the above mentioned trial experiment). It is recognized that the poloidal viscosity is the lowest in "High-Bumpy" configuration. There are no clear local maxima, commonly on these three configurations. This is a characteristic feature in Heliotron J, where the helicity and toroidicity are comparably contributing to form the magnetic field structure. Experimental verification on this characteristic will extend the systematic understandings.

This calculation results are based on assumed plasma parameters, and then, it cannot be used for the predictions for particular experiments. However, deduced knowledge will be utilized in planning bias-experiment in Heliotron J among so-far examined helical plasmas.

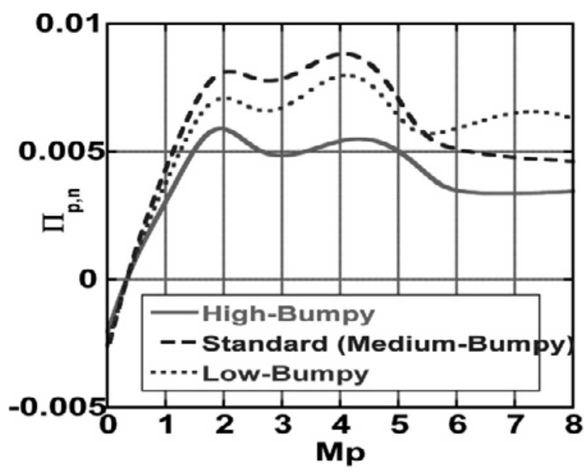

Fig.1 : Neoclassical poloidal viscosity (normalized, Ref.5)) as a function of Mp for three magnetic configurations in Heliotron J (bumpy field control).

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2) Takahashi, H., et al., Fusion Science and Tech., **51** (2007) 54.
3) Kitajima, S., Takahashi, H., et al., Nucl. Fusion, **48** (2008) 035002.
4) Kitajima, S., et al., to be presented at the 23rd IAEA Fusion Energy Conf. Daejon, Korea (Oct. 2010).
5) K.C.Shaing, Phys. Fluids B **5** (1993) 3841.