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ヘリオトロンJにおけるブートストラップ電流の磁場配位依存性
Magnetic configuration dependence of bootstrap current in Heliotron J

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Toroidal current in plasmas affects magnetohydrodynamic (MHD) equilibrium and stability in stellarator/heliotron systems since that current modifies the vacuum rotational transform. For this reason, it is important to understand the non-inductive current driving mechanism, and to control the currents in order to improve plasma confinement. The purpose of this study is to clarify the physics mechanism of bootstrap current experimentally by controlling the Fourier component of magnetic field spectrum in ECH plasma of Heliotron J.

Non-inductive currents have been measured with various magnetic configurations with Rogowski coils. In a previous study of non-inductive currents for Heliotron J, the bootstrap current and the electron cyclotron (EC) driven current were separated by comparing experiments under positive and negative magnetic fields. In this paper, EC beam is injected perpendicularly to the magnetic axis. Then, the parallel refractive index $N_{\|}$ is chosen to be 0.0 so that the EC driven current can be suppressed. Therefore, the ‘bootstrap current’ is given as the measured current under the condition of $N_{\|}$=0.0.

Figure 1 shows dependence of the bootstrap current on the bumpy component (ε_b). Red circles indicate experimental data and blue ones indicate calculation data using the SPBSC code [1]. The bootstrap current increases in the co-direction as the bumpy component increases. Figure 2 shows current density profile calculated by the SPBSC code which is based on neoclassical theory. Current density increases in the co-direction with an increase in the bumpy component . Figure 1 shows that the calculated currents are in general agreement with the experimentally measured current in the standard configuration (ε_b= 0.06) and high bumpiness configuration (ε_b= 0.15). On other hand, the measured current flows in the counter-direction at the low bumpy configuration (ε_b= 0.01), which is not consistent with the theoretical prediction. A candidate for this discrepancy is the effect of the radial electric field. The neoclassical theory predicts that the radial electric field in the electron root induces the bootstrap currents flowing in the counter-direction [2]. A further study is necessary to investigate whether the radial electric field has major influence in low bumpiness configuration.

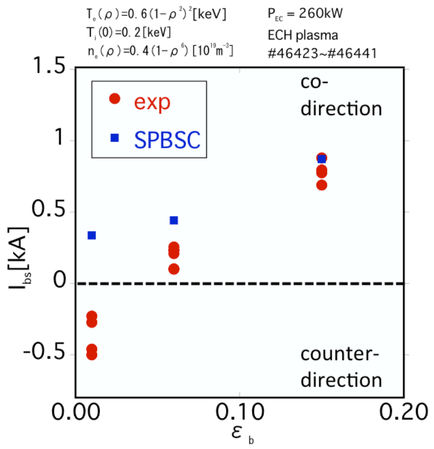

Fig.1 ε_b dependence of bootstrap current.

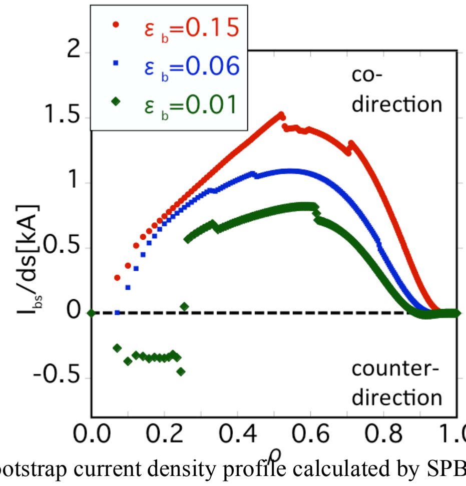

Fig.2 Bootstrap current density profile calculated by SPBSCcode.

[1] K. Y. Watanabe et al. Nucl. Fusion (1995) 35 335.

[2] G. Motojima, K. Nagasaki, et al. Nucl. Fusion 47 (2007) 1045-1052.