

Study of spontaneous transition by toroidal current control in a low magnetic shear helical device

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The control of the toroidal current in current-free helical plasmas is important for the dynamic control of the rotational transform profile and the rational surfaces. In Heliotron J, a low magnetic shear helical device, a variety of the toroidal current control has been developed not only by the electron cyclotron and/or neutral beam current drives (ECCD, NBCD) but also by the bootstrap (BS) current using the modification of toroidal mirror ripple (bumpiness) [1-3]. In this study, we report the results on the spontaneous transition window in the Co- and Counter- neutral beam injection (NBI) plasmas with respect to the bumpiness scan experiments using the three bumpy magnetic field (ε_b) configurations at $\varepsilon_b = 0.15$ (high), 0.06 (middle) and 0.02 (low). The edge rotational transforms in these configurations are slightly less than a rational number of $m/n = 7/4$, where m and n are the poloidal and toroidal mode numbers, respectively. At the middle and high bumpy field configurations, a spontaneous transition has been observed only in the Co-injected NBI plasmas. Clear characteristics of the toroidal current at the time of the $H\alpha$ intensity drop are found in the NBI power scan experiments, that is, the spontaneous transition has been occurred at almost certain toroidal currents at 0.7 ± 0.1 kA in the middle ε_b case and at 1.3 ± 0.2 kA in the high ε_b case, respectively. The positive toroidal current has a possibility to increase the rotational transform crossing the $m/n = 7/4$ surface. On the other hand, no transition was observed in the low ε_b configuration under the same conditions such as the power and density range. In this case, the measured toroidal current was low as compared with the other two configurations. From the numerical calculation, the BS current in the low ε_b configuration was expected to be low or in the opposite direction to Co-NBCD. These results suggest that the existence of $m/n=7/4$ rational surface may have a contribution to the occurrence of the spontaneous transition. We will also report the results in the configurations with the edge rotational transform around 0.5 (i.e. $m/n = 8/4$).

[1] F. Sano, *et al.*, Proc. 21st IAEA FEC 2006 Ex/5-5Ra.

[2] F. Sano, *et al.*, Nucl Fusion. **45** (2005) p1557.

[3] K. Nagasaki, *et al.*, Proc. 21st IAEA FEC 2006 Ex/P6-14.