§34. Dependence of Non-Inductive Current on Magnetic Axis in LHD Experiments under NB Balanced Injection

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In helical devices, net toroidal current is not necessary to produce the magnetic field for plasma confinement. In LHD experiments, over 100kA of net toroidal current has been observed under NB injection. In typical LHD experiments, we do not drive ohmic current actively. Then, bootstrap current and Ohkawa current are theoretically considered as the candidates of the non-inductive current source. The observed toroidal current up to now is not large enough to activate current driven instabilities. However, there is a possibility that it affects the MHD stability and transport through changing of the magnetic configurations. The toroidal current with the direction to increase the rotational transform, which we call co-direction or positive, leads to the decrease in the magnetic shear and the suppression of Shafranov shift which restrains the formation of magnetic well. The above effect is more sensitive on the current profile than the net current. In helical systems, the direct measurement of toroidal current profile is difficult because the additional change of the poloidal field to the vacuum field should be detected. Then it is important to identify the driving mechanism of the toroidal current, which leads to the construction of the reasonable model for the determination of current profile in present experiments as well as in reactor designs.

Figure 1 shows the dependence of non-inductive current obtained experimentally on beta in various magnetic axis cases. The data are obtained under a same condition of NB injection; co NB has port through power of 2MW with beam energy of 150keV, and two cntr. NBs have 0.6MW with 120keV and 1MW with 150keV, respectively. The magnetic field strength is 1.5T. The beta changes 0.1~0.6% as the volume averaged beta value, $\langle\beta_{dia}\rangle$. The obtained non-inductive current increases as beta increases, which agrees with the behavior of bootstrap current. The observed non-inductive current decreases as the magnetic axis goes torus-outwardly. Figure 2 shows the dependence of non-inductive current obtained experimentally with almost same beta values on the magnetic axis position. Here $\langle\beta_{dia}\rangle$=0.33~0.41%. Circles denote the experimental data and a line denotes the theoretical prediction of bootstrap current by SPBSC code [1]. The theoretical prediction also shows that the bootstrap current decreases with the torus-outward shift of the magnetic axis. That reason is because the magnetic configuration approaches to a poloidal symmetry system due to the torus-outward shift of the magnetic axis in LHD. It should be noted that co beam current is a little superior to cntr. beam current as the above mentioned. According to a theoretical prediction by MCNBH code [2], which is based on 3-dimensional Monte Carlo simulation, the non-inductive current driven by the beam is approximately +5kA. The effect of the unbalanced beam is not large here.

According to the dependence of obtained non-inductive current on beta and magnetic axis position, the bootstrap current is the most probable candidate as the driving mechanism of non-inductive current in LHD experiments under balanced NB injection.

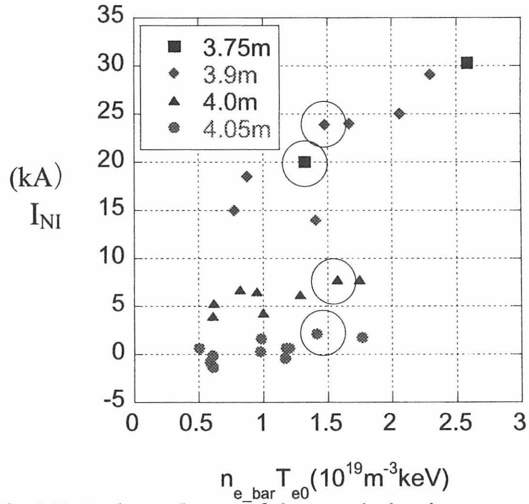

Fig.1 Beta dependence of the non-inductive current obtained experimentally under balanced NB injection with various magnetic axis positions.

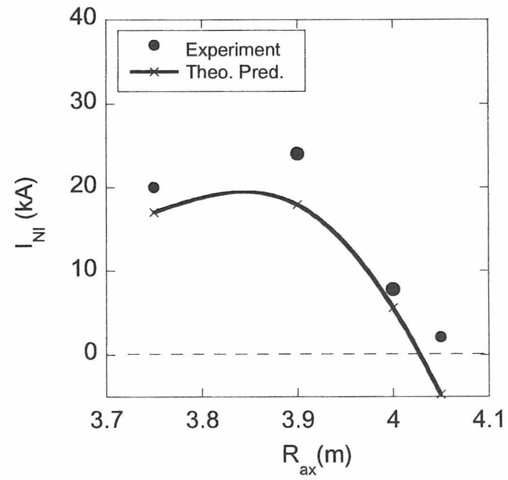

Fig.2 Magnetic axis position dependence of the non-inductive current obtained experimentally under almost same beta, and the comparison between experimental results and the theoretical prediction.

[1] K.Y. Watanabe et al, Nuclear Fusion 35, 335 (1995).
[2] S. Murakami et al, Trans. Fusion Technol. 27, 259 (1995).