§ 9. The Effect of Non-Axisymmetry of Magnetic Configurations on Radial Electric Field Transition Properties in the LHD

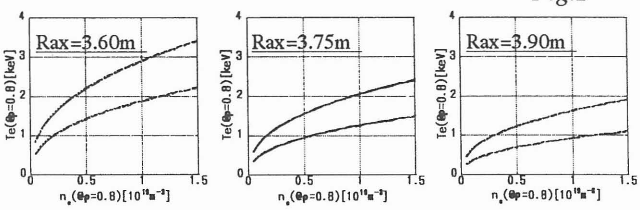
Yokoyama, M., Ida, K., Yoshinuma, M., Shimozuma, T., Watanabe, K.Y.,
Murakami, S.* (Dept. Nuclear Eng., Kyoto Univ.),
Wakasa, A.** (Graduate Sch. Eng., Hokkaido Univ.),
Kubo, S., Takeiri, Y., Narihara, K., Morita, S.,
Tanaka, K., Yoshimura, Y., Notake, T., Osakabe, M.,
Itoh, K., Komori, A., Motojima, O.,
LHD Experimental Group

The transition properties of the radial electric field (E_r) have been theoretically and experimentally examined in the Large Helical Device (LHD) to grasp inter-relationships between magnetic configuration characteristics and E_r properties [1,2]. The E_r is calculated based on the ambipolar condition with the neoclassical flux estimated by the analytical formulae [3]. The effective helicity, $\varepsilon_{h,eff}$, used for flux calculations is estimated with the GIOTA code [4], which is based on the bounce-averaging method for evaluating neoclassical ripple transport. The E_r transition utilizing the non-axisymmetry of magnetic configurations in helical systems is focused, which is possible through the nonlinear dependence of plasma transport on E_r. This study is valuable to utilize E_r transition for confinement improvement in non-axisymmetric configurations.

One of knobs for controlling $\varepsilon_{h,eff}$, in the LHD is the control of the vacuum magnetic axis position R_{ax}. Fig.1 shows E_r-diagram on (n_e,T_e) plane for three cases with different R_{ax} : 3.60m, 3.75m, and 3.90m. The calculations are performed at ρ=0.8 with B = 1.5 T. The hydrogen plasma is assumed. The assumed n_e and $T_{e,i}$ profiles are $n_e(\rho)=1\times10^{19}(1-\rho^8)$ m^{-3} and $T_{e,i}(\rho)=T_{e,i}(0)(1-\rho^2)$ keV with assuming T_e=T_i. The E_r is positive above the upper boundary and negative below the lower boundary. The region between two boundaries corresponds to the region of multiple E_r solutions. The $\varepsilon_{h,eff}$ is estimated as about 0.05, 0.14, and 0.27 for cases with R_{ax} =3.60m, 3.75m, and 3.90m, respectively. It is recognized that $\varepsilon_{h,eff}$ varies largely depending on the control of R_{ax}. It can be clearly read that the threshold density for entering region of multiple E_r solutions and/or electron root decreases as $\varepsilon_{h,eff}$ decreases for a same temperature.

The experimental results reasonably consistent with this theoretical prediction have been obtained recently in LHD. The threshold density for the transition from ion to electron root has been observed to become lower as Rax is decreased (more inwardly shifted) [5], which will also be presented in the workshop. This agreement has given the proof that the Er transition properties in LHD are predominantly determined based on the neoclassical transport. Based on this, the dependence of the threshold ECH power on configuration variation for establishing the electron internal transport barrier [6] would also be the interesting subject based on this study.

Fig.1



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