§33. Analysis of the Radial Electric Field (Electron Root) and its Impact on Plasma Confinement in LHD

Yokoyama, M., Ida, K., Yoshinuma, M., Beidler, C.D. (Max-Planck, Greifswald), Takeiri, Y., Nakamura, Y., Shimozuma, T., Murakami, S. (Kyoto Univ.), Watanabe, K.Y., Kubo, S., Narihara, K., Morita, S., Tanaka, K., LHD Experimental Group

The interrelation between the non-axisymmetry of magnetic configuration and the property of radial electric field has been focused to clarify the impact of the electron root on plasma confinement in LHD.

The control of the magnetic axis position (R_{ax}) is one of the important knobs to vary the non-axisymmetry of magnetic configuration. The prediction based on the neoclassical transport theory, that is, the electron root becomes possible for higher collision frequency for a magnetic configuration with enhancing non-axisymmetry, has been experimentally verified with a density scan experiment for magnetic configurations with different R_{ax}. This experimental verification has been accumulated especially for the edge region due to the capability of radial electric field measurement for configurations with wide range of R_{ax}.

On the other hand, experimental results for electron internal transport barrier (eITB) formation have also been accumulated for various configurations with various R_{ax}. It has been pointed out that the eITB formation seems to be very much related to the realization of the electron root in a core region [1] (such as the threshold electron temperature (in other words, threshold ECH power) and its density dependence). Based on this tendency and the above mentioned knowledge, the 'electron root capability' is affected by the non-axisymmetry of a magnetic configuration, the systematic investigation of 'electron root capability' in a core region for configurations with different R_{ax}, is certainly interesting to promote the eITB physics peculiar in non-axisymmetric configurations.

However, the non-axisymmetry of a magnetic configuration is rather small at a core region in LHD due to the fact that helical coil-induced helical ripples decrease towards the magnetic axis. Thus, rather accurate evaluation of the ripple diffusion (key to occur the transition from ion to electron root [2]) is required based on the accurate consideration of magnetic ripples. For this purpose, GSRAKE code [3] was implemented in cooperation with Dr. C.D.Beidler.

The GSRAKE has been rather well benchmarked to other numerical codes for neoclassical transport [4]. The modification of GSRAKE has been progressed to make it more suitable for LHD experimental data analysis/making experimental scenario. The application of GSRAKE to examine eITB physics is also coming soon.

The avoidance of the impurity accumulation in a low collisional regime has been pointed out that the electron root provides the outward particle flux to expel the impurity [5]. This would be the favorable feature for considering helical reactors. Based on the above mentioned feature that the interrelationship between the electron root capability and the non-axisymmetry of magnetic configuration, it is anticipated that the density range of the density window for impurity accumulation might be varied according to the Rax variation through the variation of the non-axisymmetry of magnetic configuration. The experiment to compare the density window for magnetic configurations with different Rax was conducted using the long pulse discharges. The density range of the window for the impurity accumulation varies depending on the magnetic configuration. This interesting feature will also be considered from the viewpoint of the electron root capability for different magnetic configurations.

References

1) Yokoyama, M., et al., J.Plasma and Fusion Res. **79**, (2003) 816.
2) Yokoyama, M., et al., Nucl. Fusion **42**, (2002)143.
3) Beidler C.D., et al., Plasma Phys. Control. Fusion **36**, (1994) 317.
4) Beidler C.D., et al., Proc. 14th International Stellarator Workshop, (Greifswald, Sep. 22 - 26, 2003) P.Mo13.
5) Nakamura, Yukio, et al., 19th IAEA Fusion Energy Conference (2002), EX/C5-1.