

§16. Studies on Electric Field and Confinement in Helical Systems

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An important role of the electric field and/or plasma rotation on the suppression of micro-instabilities and the improved confinement has been widely recognized in various devices with different configurations, sizes and plasma parameters. The experimental observations in tokamaks as well as stellarators have provided the database for an increased understanding of the physics associated with radial electric field. Various theoretical models have been proposed and predicted the structural change of electric field in connection with the L/H transition.

Recent considerable progress on both the theoretical modelling and measurement techniques such as the charge exchange recombination spectroscopy(CXRS), heavy ion beam probing(HIBP) and laser-blow-off lithium beam probing may realize the detailed analysis of electric field profile in the whole plasma region and its influence on improved confinement. Particularly, the Compact Helical System(CHS) experiment, in which the electric field profile in the whole plasma region can be evaluated from both toroidal and poloidal rotation velocities and pressure gradient by using the CXRS data, really encourages the study on the electric field generation mechanism and its fine structure.

During past few years, we discuss a theoretical model to determine the electric field in heliotron/torsatron and an understanding of the cooperative mechanism among the electric field, loss of energetic particles, and confinement characteristics. In

general, the electric field is determined by balancing the driving forces with the drag forces. There are essentially two type of forces to drive rotations: one is the force associated with momentum transport due to, for example, neutral beam injection and the other is the bipolar fluxes caused by electron and ion diffusions. Also, several approaches for the active control of electric field have been discussed, which are by driving plasma rotation with neutral beam injection into plasma, by controlling ion and electron losses with NBI or electron cyclotron heating(ECH), due to biasing(electrode, limiter, divertor, etc.), so on. We have discussed the physical mechanism of the generation and structure of electric field with NBI, ECH and biasing in tokamaks as well as in stellarators.

The electric field in the steady state is evaluated by the ambipolarity equation, which consist of the neoclassical fluxes, the direct orbit loss flux, the charge exchange contribution of fast ions, RF-induced flux, and that by anomalous transport. As for the anomalous flux, we discussed a theoretical model in which the flux is evaluated on the basis of the ion temperature gradient(ITG) mode and the model is applied to compare the theoretical predictions with the experimental observations. The detailed discussions will be reported elsewhere.

References

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