Numerical study on formation process of helical nonneutral plasmas using electron injection from outside magnetic surfaces

K. Nakamura, H. Himura, M. Isobe[a], A. Sanpei, S. Masamune

Kyoto Institute of Technology, Department of Electronics,
Matsugasaki, Sakyo Ward, Kyoto 606-8585, Japan
[a]*National Institute for Fusion Science, 322-6 Oroshi-cho, Toki 509-5292, Japan*

e-mail address of submitting author: nakamu6t@nuclear.dj.kit.ac.jp

We show a full set of calculation results on electron orbits which extend to the inward part of closed helical magnetic surfaces (HMS). This work actually provides the setup conditions of initial electrons launched from an electron gun placed on the stochastic magnetic region (SMR) surrounding the last closed surface (LCFS) of the HMS.

It has been experimentally confirmed [1] that helical nonneutral plasmas can be produced with thermal electrons launched from the outside of LCFS in which magnetic islands are overlapped and chaotic lines of force are presented. The formation process proceeds in quite short time which is about 150 μs much shorter than any binary collision times. As a possible mechanism, our recent computation [2] has proposed the effect of large self space potential ϕ_s on the injected electrons. Due to the large ϕ_s, the pitch angle of the injected electron is scattered considerably in the SMR. Eventually, the injected electron turns to be a helically trapped particle, and start an inward movement along one of the $|B_{min}|$ contours. Once penetrating deeply, the electron can never escape from the LCFS because ϕ_s in the SMR acts as a potential barrier for the electrons propagating from the innermost part of the magnetic surfaces to the LCFS. However, contrary to the experimental observation, the penetrating electrons exist in quite narrow region on the velocity map, which are the vicinities of $v_\perp/v_\parallel = 40^\circ$, and 150° [3]. Also, no penetration has occurred with relatively lower energy of the injected electrons, although it certainly happens in experiments. This discrepancy is possibly due to the assumption of completely static ϕ_s in the computation.

In this work, we model the time variation of ϕ_s and incorporate it in computation. All experimental parameters such as $|\vec{B}|$ and R_{ax} are systematically changed. Whole velocity maps and orbital motion of injected electrons are described in this presentation. Finally, comparison with experiments performed on CHS is addressed.

[1] H. Himura *et al.*, Phys. Plasmas **11**, 492 (2004); H. Himura *et al.*, Phys. Plasmas **14**, 022507 (2007).
[2] K. Nakamura *et al.*, submitted to Phys. Plasmas (2008).
[3] K. Nakamura *et al.*, submitted to Journal of Plasma and Fusion Res. Series (2008).