§23. Production of Strong Electric Field and Electron Confinement by Electron Injection into Helical System through Stochastic Region

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I. Inward penetration of electrons into helical vacuum magnetic surfaces via stochastic magnetic region [1-3]

Electrons are injected into a stochastic magnetic region (SMR) of CHS (the Compact Helical System device) vacuum configuration. Remarkably, when the SMR is present, some field-following electrons in the SMR move inwardly across the last closed flux surface. This is clearly recognized from Fig. 1 in which data of space potential $\phi_s(\psi)$ formed by the penetrated electrons is described. Here, ψ is the normalized flux surface of the CHS helical configuration. Data shows that the inward penetration of the injected electrons occurs in a collisionless process, but it is never observed for cases where the SMR is lost, nor is the electron density small in the SMR. These results suggest the existence of cross-field transport that is associated with free-streaming of electrons along the stochastically wandering field lines in the SMR. Details of the observation of the collisionless penetration of electrons via the SMR can be found in Refs. [1-3].

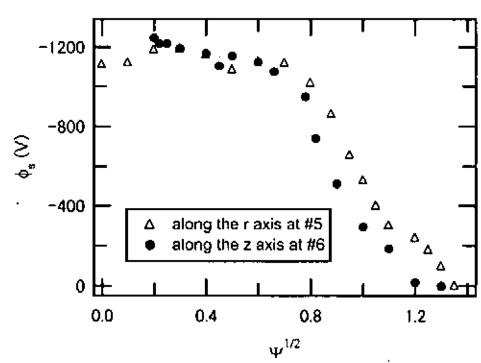

Fig. 1. Comparison of $\phi_s(r)$ with $\phi_s(z)$. These resemble each other, showing that the penetrated electrons spread along the helical magnetic surfaces.

II. Applicability of high-impedance emissive probe for large space potential of helical electron cloud [4]

Space potential ϕ_s of non-neutral plasmas with low density of $n_e \sim 10^{12}$ m^{-3} are measured by two floating emissive probes. Nothing is difference between them except the area S of filaments. Despite the thermionic current is sufficiently emitted, floating potential ϕ_f outputted from the smaller filament are much larger than the realistic ϕ_s at some measurement points, which is contrary to the widely-known relation of $\phi_f \leq \phi_s$ in probe measurements. The result is attributed to the insufficient probe current I_p collected in low-n_e plasmas with large ϕ_s. This is because, in such a plasma, I_p does not always satisfy the necessarily condition of $I_p > \phi_s/R_{HI}$ where R_{HI} is a high impedance resistor, although the value of I_p required for the floating emissive method is very small. In order to correctly determine ϕ_s of the plasmas, S must be larger than $\phi_s/en_e\langle v_e\rangle R_{HI}$ where e electron charge and $\langle v_e\rangle$ mean speed of electrons collected to the probe. Details of this topic can be found in Refs. [4].

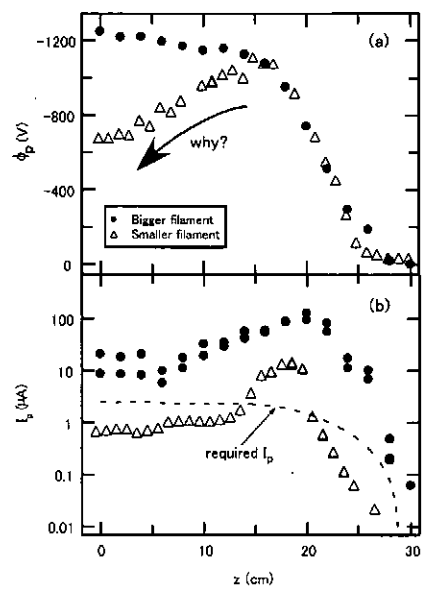

Fig. 2. Vertical profiles of (a) space potential ϕ_s, (b) probe current I_p ($\propto$ electron flux Γ_e) at $V \sim \phi_s$ measured in CHS helical nonneutral plasmas.

III. Influence of transverse magnetic field on extracting electron beam injected into helical configuration [5, 6]

Injection of charge particle and plasma (or plasmoid) into helical magnetic surfaces via a stochastic magnetic layer has widely been considered for the purposes of particle fueling in the plasma core, triggering plasma flow at the plasma boundary, trapping high-energy anti-particles without a technique of deceleration, and recently producing helical non-neutral plasmas. Unlike ax-symmetric geometry, any studies have required to be carefully calculated and experimented because of the three dimensional magnetic configuration. With doing the experiments described above, we simultaneously examined the characteristics of the electron beam which was accelerated and sequentially ejected in the SMR. The findings will be published soon.

Reference

1) H. Himura *et al.*, Phys. Plasmas **11**, p.492-495 (2004).
2) H. Himura et al., in *Non-Neutral Plasma Physics V* (American Institute of Physics, New York, 2003) p. 293-301.
3) H. Himura *et al.*, *accepted for publication in IEEE transactions on plasma science* **32** (2004).
4) H. Himura *et al.*, Rev. Sci. Instrum. **74**, p.4658-4662 (2003)
5) H. Wakabayashi, H. Himura *et al.*, in *Non-Neutral Plasma Physics V* (American Institute of Physics, New York, 2003) p.332-335.
6) H. Wakabayashi *et al.*, will be submitted.