§28. Study on the Mechanism of Collisionless Inward Penetration of Electrons via Stochastic Magnetic Region and Experimental Investigation of Energetic Electron Trap in Helical Magnetic Surface

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In the last year, we have verifed the variation of ϕ_s and n_e on magnetic surfaces of helical electron plasmas and the paper explaining the detail of it is now under reviewed[1].

Plotted data in Fig. 1 are $\phi_s(z)$ measured by a probe with the high-impedance emissive method Three profiles of $\phi_s(z)$ are obtained for cases of V_{acc} = 300 V, 600 V, and 1 kV, respectively. The horizontal axis is shown in $\Psi^{1/2}$. Here, $\Psi^{1/2}$ = 0 and 1 correspond to the R_{ax} and LCFS, respectively. In experiments, R_{ax} is fixed at R = 101.6 cm. Thus, magnetic surfaces do not touch the grounded chamber wall. And, for this setting, the probe does not cross R_{ax}, being shifted about 4 cm inward from R_{ax}. Consequently, the lower limit of measurement points of $\phi_s(z)$ is $\Psi^{1/2} = 0.3$ on this cross-section. Substantial difference between two values of ϕ_s (at $z > 0$ and at $z < 0$) at each magnetic surface (at same value of $\Psi^{1/2}$) is observed in the region of $0.3 < \Psi^{1/2} < 1$. This means that ϕ_s is never constant on magnetic surfaces. Also, as clearly recognized from the plotted data for V_{acc} = 1 kV, the difference in ϕ_s becomes larger in the outer region of magnetic surfaces. For example, at $\Psi^{1/2} \sim 0.8$ the difference reaches about 200 V, while at $\Psi^{1/2} \sim 0.3$ it almost disappears. Such a difference in ϕ_s still appears even when V_{acc} is decreased, as shown with white (V_{acc} = 600 V) and black triangles (V_{acc} = 300 V). However, for these cases, the difference between the two values of ϕ_s at each magnetic surface becomes smaller. Another significance is that despite V_{acc} is changed, measured $\phi_s(z)$ in $z > 0$ are always (negatively) larger than those in $z < 0$. Meanwhile, on this cross-section, helical magnetic surfaces are slightly shifted downward with respect to the center of the elliptic chamber wall. Considering contours of ϕ_s (equi-potential surfaces) from the measured $\phi_s(z)$, the ϕ_s contours are expected to shift upward with respect to the contours of constant ψ (magnetic surfaces). We have so far obtained only two values of ϕ_s at each magnetic surface, it suggests that equi-potential surfaces move away from the closest part of the grounded chamber wall.

In this research, the current-voltage (I_e-V_p) characteristics are also measured at each magnetic surface with the same emissive probe. For this measurement, the impedance of the probe is changed to a low impedance (330 Ω) so as to obtain I_e that flows out from the plasma through the probe. From the I_e-V_p characteristic curve, we have determined the electron temperature T_e. Regarding with n_e, it is obtained from I_e ($\sim e n_e v_{th} S$) at $V_p = \phi_s$, where ϕ_s has been pre-measured just before the I_e measurement, where v_{th} is electron thermal speed and S is the probe area. All other contributions to I_e except v_{th} are ignored, because v_{th} is much faster for the presented hot plasmas. Figure 2 shows $n_e(z)$ for B = 0.9 kG and V_{acc} = 600 V. As can be seen from the plotted data, n_e is also non-constant on each magnetic surface. Significantly, unlike ϕ_s, values of n_e near LCFS ($\Psi^{1/2} = 1$) is larger in the $z < 0$ region (white circles) than those in $z > 0$ (black circles). This means that electrons tend to move towards the grounded chamber wall. This can be understood from the shift of $\phi_s(z)$. As explained, the envisioned contours of ϕ_s have shifted upward with respect to the contours of constant ψ. In that case, the corresponding (global) direction of $E_{//}$ in the poloidal cross-section results in the upward direction as well. Therefore, electrons are forced toward the downward side ($z < 0$) of the magnetic surfaces. In fact, this result seems also to be consistent with the stability analysis for nonneutral plasmas confined in magnetic surfaces.

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[1] H. Himura, H. Wakabayashi, Y. Yamamoto *et al.*, *submitted to Phys. Plasmas* (2006).

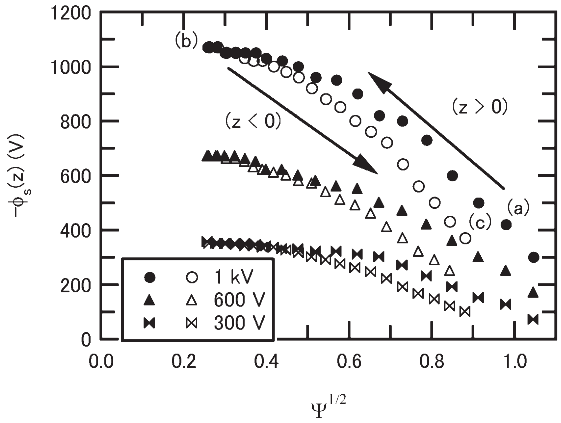

Fig. 1 Typical potential profile of CHS nonneutral plasma.

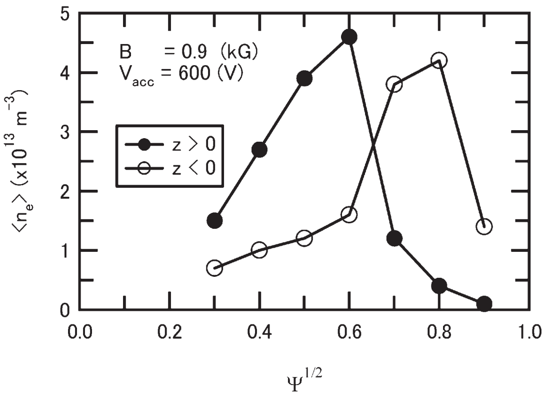

Fig. 2 Typical electron density profile of CHS nonneutral plasma.