

### §30. Observation of Space Potential Variation on Magnetic Surfaces on CHS

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Magnetic surface is one of the most important and fundamental concepts in toroidal plasma confinement devices such as tokamaks and stellarators. In quasi-neutral fusion plasmas, physical parameters such as density and potential are thought to be constant on a magnetic surface.

However, in low density electron plasmas with finite temperature and irregular density, that is not the case. The parallel component of equilibrium force balance is written as

$$en_e \nabla_{\parallel} \phi_s = \nabla_{\parallel} p,$$

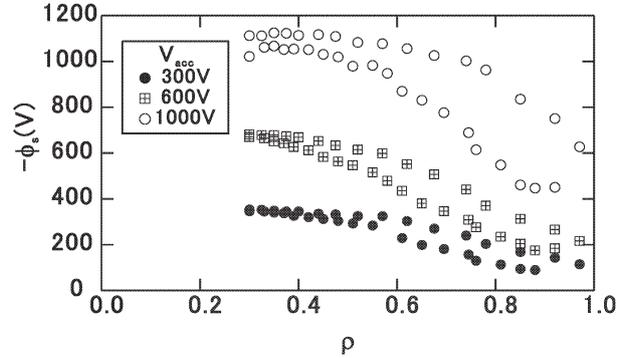
where  $\nabla_{\parallel}$  and  $\phi_s$  stands for derivative along a magnetic field line of force and the space potential, respectively. Assuming that  $T_e$  is constant on the magnetic surfaces, this equation can be written as

$$en_e \nabla_{\parallel} \phi_s = T_e \nabla_{\parallel} n_e,$$

which leads to the Maxwell-Boltzmann distribution. As we can see in the equation above, if  $T_e$  is finite and there is steep gradient of  $n_e$ , the pressure gradient should be balanced with the parallel component of the electric force by the potential gradient. So  $\phi_s$  can vary along the magnetic field lines of force, as well as on the magnetic surfaces.

In our experimental studies on electron plasmas, we have investigated the  $\phi_s$  profile of the electron plasma on helical magnetic surface configuration. And we have observed that there are cases on which  $\phi_s$  is not uniform on each magnetic surface. The experiments were performed in CHS. An electron gun (e-gun) is inserted horizontally in 2-O port of the CHS along the  $r$  axis. Electrons are launched out into the vacuum magnetic field  $B \sim 0.09T$  from the e-gun with acceleration voltage  $V_{acc}$  up to

1kV and emission beam current  $I_b$  up to 100mA. The electron plasma is generated by continuous injection of electrons for 40ms. For diagnostics, a Langmuir emissive probe is inserted vertically on 6-U port along the  $z$  axis. The probe is terminated with 100M $\Omega$  impedance to measure the space potential  $\phi_s$  of the electron plasma.



**Fig. 1 Profiles of  $\phi_s$  measured on the 6-U port of CHS. Two series of  $\phi_s$  are recognized for each  $V_{acc}$ , insisting that  $\phi_s$  is not constant on each magnetic surface. The e-gun is placed at  $\rho=0.9$ .**

Figure 1 shows profiles of  $\phi_s$  plotted against the normalized minor radius  $\rho$ . Three data sets are shown for  $V_{acc}=300V$ , 600V and 1kV. The position of the e-gun is 0.9 in this measurement.

Substantial differences of  $\phi_s$  are clearly recognized on each magnetic surface, especially at the boundary region of the electron plasma. Two profiles of  $\phi_s$  for each  $V_{acc}$  are measured in the  $z>0$  and  $z<0$  regions each other, and values at  $z>0$  are negatively larger than  $z<0$ . The difference between the two series is almost proportional to  $V_{acc}$ , which implies that the variation is closely related to the electron energy.

By a dimensional analysis of the force balance equation, one can find that the value of potential variation along a magnetic field line of force can be on the same order of  $T_e$ . On our experimental situation  $T_e$  is not known properly so far, but it is estimated to be some hundreds of eV, which seems to be approximately consistent with the observed potential variations. Further investigations quantitatively verifying the potential variations will be shown later.