# §12. Control of Thermal and Particle Transport by Electrostatic Potential Formation in a Plasma

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The formation and control of electric field in a plasma is a very important issue in fusion plasmas. In the confinement-improved mode, suppression of density fluctuations of the drift mode and/or the flute mode has been often observed to be associated with formation of a rotational shear flow driven by a large radial electric field and its shear. Recently, we have demonstrated that the rotation frequency shear of net ion drift which is determined from both $E \times B$ drift and diamagnetic drift is important for stabilizing the drift mode[1]. In this experiment, however, there exists neutral gas and the collision effects on the fluctuations must be considered. Thus, it is necessary to carry out experiments in a fully-ionized plasma from the viewpoint of making a comparison with results in collisionless plasmas of large devices. Purpose of the present experiment is to investigate detailed behaviors of low-frequency fluctuations in the Q-machine device as a fully-ionized plasma source.

Experiments are performed in the $Q_T$−Upgrade machine of Tohoku University as shown in Fig. 1. A plasma is produced by surface ionization of potassium atoms on a 10-cm-diam tungsten (W) hot plate under an electron-rich condition and is confined by a magnetic field of 1.6 kG in a single-ended Q machine. The hot plate is concentrically segmented into three section, each of which is electrically isolated and is individually biased. Thus, the radially-different plasma potential, or radial electric field is generated even in the fully-ionized collisionless plasma. Hereinafter, the electrodes set in order from the center to the outside are called as the first, second, third electrodes and the voltages applied to them are defined as $V_{H1}, V_{H2}, V_{H3}$, respectively. Under our conditions, the plasma density $n_p = 2 \times 10^9$ cm$^{-3}$, the electron temperature $T_e = 0.2$ eV, and the ion temperature $T_i \leq T_e$. A background gas pressure is less than $1 \times 10^{-6}$ Torr.

Radial profiles of floating potential $\phi_f$ are presented in Fig. 2(a) with $V_{H1}$ as a parameter for $V_{H2} = V_{H3} = 0$ V at $z$ = 60 cm from the hot plate. As usual in the Q-machine plasma under an electron-rich condition, the plasma (floating) potential is negative in the radial center of the plasma column and increases towards the edge region. When $V_{H1}$ is changed from −1.4 V to −0.3 V, the floating potential profile in the central region is changed from the well shape to the hill shape, while that in the edge region is almost constant. The potential difference in the central region can be controlled in a range of $-5 \sim 5$ V with the accuracy of 0.05 V.

Figure 2(b) shows frequency spectra of the electron saturation current of the probe as a function of $V_{H1}$, which are observed at $r = -2.5$ cm and $z = 60$ cm. As $V_{H1}$ is increased, the fluctuation amplitude is found to increase, gradually decreasing for $V_{H1} > -0.6$ V. The frequency of the spectrum peak is about 20 kHz, which corresponds to the frequency of the drift instability Doppler-shifted due to the $E \times B$ drift. When the fluctuation amplitude has the maximum value for $V_{H1} \simeq -0.6$ V, the radial profile of floating potential is almost flat in the central region. This result indicates that the drift instability excited in the edge region is suppressed by the radial electric field generated by biasing the divided hot plate in the Q-machine plasma.

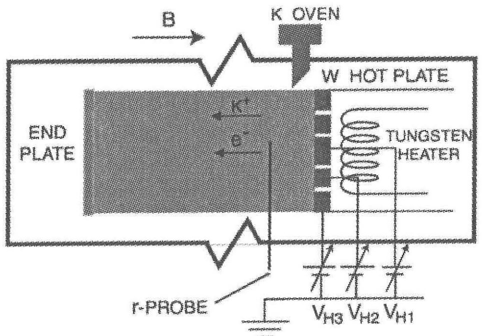


Fig. 1. Schematic of experimental setup.

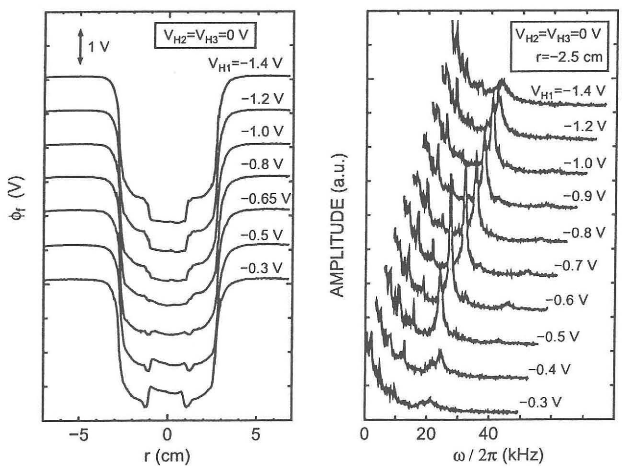


Fig. 2. (a) Radial profiles of floating potential $\phi_f$ and (b) frequency spectra of the electron saturation current with $V_{H1}$ as a parameter for $V_{H2} = V_{H3} = 0$ V at $z = 60$ cm from the hot plate. The frequency spectra are measured at $r = -2.5$ cm.

Reference

1) Yoshinuma, M., *et al.*, Trans. Fusion Tech. **39**, (2001) 191.