# DRIFT-LIKE INSTABILITIES MODIFIED BY THE PERPENDICULAR FLOW SHEAR IN A FULLY-IONIZED COLLISIONLESS PLASMA

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## ABSTRACT

The drift-like instability existing in the edge region, where the density gradient is relatively large, is observed to be suppressed by the perpendicular flow shear in the central region. When the perpendicular flow shear is more increased, another kind of instability localized in the shear region is observed. The frequency of this instability is radially constant, and increases or decreases with depending on the sign of shear. This instability is considered to be the coupled drift and Kelvin-Helmholtz instability, which is enhanced by the perpendicular flow shear.

## INTRODUCTION

The sheared flow perpendicular to magnetic field lines in a plasma is a very important issue not only in the near-Earth space plasma but also in fusion plasmas. In the space plasma, a number of observations now indicate a correlation between low-frequency instabilities and transverse ion energization with the sheared cross-field (perpendicular) plasma flows [1]. In the fusion plasma, on the other hand, the suppression of density fluctuations has been often observed to be associated with the formation of perpendicular sheared flows. Recently, it has been demonstrated that the net ion-flow shear which is determined from both ExB drift and diamagnetic drift is important for stabilizing the drift mode [2]. In this experiment, however, there exists neutral gas and collisional effects on the fluctuations may have to be considered. Thus, it is necessary to carry out experiments in a fully-ionized plasma from the viewpoint of making a reasonable comparison with results in collisionless space or fusion-oriented plasmas. The purpose of the present experiment is to investigate detailed behaviors of the low-frequency fluctuations excited or suppressed by the perpendicular flow shears in the Q-machine device as a fully-ionized plasma source.

## EXPERIMENTAL RESULTS AND DISCUSSION

Experiments are performed in the $Q_T$-Upgrade machine of Tohoku University. 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 sections, 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 is $10^9$ $cm^{-3}$, the electron temperature is 0.2 eV, and the ion temperature is almost the same as the electron temperature. A background gas pressure is less than $10^{-6}$ Torr.

As usual in the Q-machine plasma under an electron-rich condition, the plasma potential is negative in the radial center of the plasma column and increases towards the edge region. When $V_{H1}$ is changed from negative to positive, the plasma 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. This radially-different plasma potential, or the radial electric field causes the ExB flow and flow shear perpendicular to the magnetic-field lines. When the radial profile of plasma potential in the central region is almost flat ($V_{H1}$ = -0.6 V), or perpendicular flow shear does not exist, a low-frequency instability is observed in the edge region where the density gradient is relatively large. The frequency of this instability is about 20 kHz, which corresponds to the frequency of the drift instability Doppler-shifted due to the ExB drift in the edge region. The fluctuation amplitude of this instability is found to decrease as $V_{H1}$ is both increased and decreased from -0.6 V. This result indicates that the drift instability excited in the edge region is suppressed by the perpendicular flow shear in the central region. When the absolute value of $V_{H1}$ is more increased, namely larger perpendicular shear is generated, another kind of instability localized in the shear region is observed. The frequency of this instability is radially constant, and increases or decreases with depending on the sign of shear. This instability is considered to be the coupled drift and Kelvin-Helmholtz instability, which is enhanced by the perpendicular flow shear.

## REFERENCES

[1] W. E. Amatucci, "Inhomogeneous plasma flows: A review of in situ observations and laboratory experiments," *J. Geophys. Res.*, vol. 104, pp. 14481-14503, July 1999.

[2] M. Yoshinuma, M. Inutake, K. Hattori, A. Ando, T. Kaneko, R. Hatakeyama, and N. Sato, "Effects of radial electric field and its shear on low-frequency fluctuations in the $Q_T$-U device," *Trans. Fusion Tech.*, vol. 39, pp. 191-194, January 2001.