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Effects of Perpendicular Shear Superposition and Hybrid Ions Introduction on Parallel Velocity-Shear Driven Plasma Instabilities.

R. Hatakeyama
Tohoku University
Sendai, Japan

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R. Hatakeyama and T. Kaneko

Department of Electronic Engineering, Tohoku University, Sendai 980-8579, Japan

E-mail : hatake@ecei.tohoku.ac.jp

In recent studies, the ion flow velocity shear parallel to magnetic field lines has been reported to enhance the drift-wave instability in magneto plasmas [1,2], while the perpendicular shear has been confirmed to suppress the instability independently of the sign of the shear. In order to clarify the mechanisms of excitation and suppression of these instabilities in the real situation of space and fusion plasmas, it is necessary to realize the controlled superposition of the parallel and perpendicular shears in the magneto plasmas. Furthermore, the shear-modified instability should be extended to a more general case, namely, effects of several kinds of positive and negative ions (hybrid ions) on the instability should be taken into account because the actual plasmas often contain the hybrid ions.

Experiments are performed in the Q_T-Upgrade machine of Tohoku University. We attempt to modify a plasma-synthesis method with opposed electron and potassium ion (K^+) emitters, where both the emitters are concentrically segmented into three sections [3]. When each of the electron and ion emitters is individually biased, the perpendicular and parallel ion flow velocity shears can be generated, respectively, and superimposed on each other. Under our conditions, the plasma density is 10^8 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.

The fluctuation amplitude of the drift wave which has an azimuthal mode number m=3 is observed to increase with increasing the parallel shear strength, but the wave is found to be gradually stabilized when the shear strength exceeds a critical value. When the perpendicular shear is superimposed on the parallel shear, the drift wave of m=3 is found to change into that of m=2 through a broadband turbulence state. Furthermore, the parallel shear strength required for the excitation of the drift wave becomes large with a decrease in the azimuthal mode number. Based on these results, the superposition of the parallel and perpendicular shears can affect the characteristics of the drift wave through the variation of the azimuthal mode number.

On the other hand, the effects of a negative ion (SF_6^-) as one of the hybrid ions on the drift wave in the presence of the sheared field-aligned positive-ion (K^+) flow have also been investigated [4]. The negative ion is found to stabilize the shear-modified drift wave, which is the opposite result to a number of earlier studies on the negative ion plasmas. Considering dependence of the wave properties on the hybrid ions is of great help to characterizing the shear-modified plasma instabilities.

[1] T. Kaneko, H. Tsunoyama, and R. Hatakeyama, Phys. Rev. Lett. **90** (2003) 125001.
[2] T. Kaneko, E.W. Reynolds, R. Hatakeyama, and M.E. Koepke, Phys. Plasmas. **12** (2005) 102106.
[3] T. Kaneko, Y. Odaka, E. Tada, and R. Hatakeyama, Rev. Sci. Instrum. **73** (2002) 4218.
[4] R. Ichiki, K. Hayashi, T. Kaneko, and R. Hatakeyama, Trans. Fusion Sci. Technol. **51** (2007) 241.