MODE CONVERSION OF PARALLEL-FLOW-SHEAR DRIVEN LOW-FREQUENCY INSTABILITIES BY THE REVERSAL OF SHEAR SIGN IN A PLASMA

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ABSTRACT

Parallel flow shears in magnetized plasmas are experimentally found to give rise to several types of low-frequency instabilities. When the sign of shear is positive, the fluctuation propagating to the azimuthal direction is observed around the region of the parallel flow shear. When the shear sign is negative, on the other hand, the axial wave number of the observed fluctuation becomes relatively large in comparison with the case of the positive shear sign. These instabilities are considered to be related to the Kelvin-Helmholtz instability driven by the shear and the ion-acoustic-like instability modified by the shear, respectively.

INTRODUCTION

It is well known that field-aligned sheared flows in laboratory devices and in the natural space environment give rise to low-frequency instabilities called Kelvin-Helmholtz modes [1]. However, a recent kinetic analysis indicates that the field-aligned flow shears can cause not only the Kelvin-Helmholtz instability but also electrostatic ion-cyclotron, ion-acoustic, and drift wave instabilities [2]. Therefore, we claim that the laboratory experiments, where the ion flow shears parallel to the magnetic field lines are externally controlled, are necessary to clarify general features of the origin of these instabilities. The aim of the present work is to realize the generation of the parallel ion flows and flow shears, demonstrating the existence of and the difference between these new kinds of instabilities experimentally.

EXPERIMENTAL RESULTS AND DISCUSSION

Experiments are performed in the Q_T-Upgrade machine of Tohoku University. For the purpose of the generation of the parallel flow-shear, we attempt to modify a plasma-synthesis method with oppositing electron and potassium ion sources. Ion and electron emitters of the same diameter are oppositely set at cylindrical machine ends under a strong magnetic field of 1-3 kG. Under our conditions, the plasma density is about 10^9 cm^{-3}, the electron temperature is around 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 ion emitter is concentrically segmented into three sections. Since the electron-emitter voltage applied determines the plasma potential, the field-aligned ion flows with radially different energies are generated in the radially uniform plasma potential when each section of the segmented ion emitter is individually biased at a positive value above it. This ion drift difference between adjacent layers, or parallel ion flow shear is found to give rise to several types of low-frequency instabilities. When the ion flow energy in the central region (ε_1) is smaller than that in the peripheral region (ε_2), or a sign of shear is positive, the low-frequency fluctuation propagating to the azimuthal direction is observed around the region of the parallel flow shear. The frequency of this fluctuation is a few kHz, which corresponds to the diamagnetic drift frequency, and gradually increases with an increase in ε_1. When the shear sign is negative, on the other hand, the axial wave number of the observed fluctuation becomes relatively large in comparison with the case of the positive shear sign. Furthermore, the frequency gradually decreases when ε_1 is increased, which is a tendency different from the result in the case of the positive shear.

From these results, it is found that the characteristics of the above-mentioned instabilities change when the sign of shear is reversed, namely a mode conversion occurs. These instabilities are considered to be related to the Kelvin-Helmholtz instability driven by the parallel flow shear [1] in the former case and the ion-acoustic-like instability modified by the shear [3] in the latter case.

REFERENCES

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