Effects of Two-Component Ions on Plasma Flow-Shear Driven Instabilities

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Recently, it has been clarified that a drift wave is excited and suppressed depending on ion flow velocity shears parallel and perpendicular to magnetic field lines [1]. To extend these results to multi-component ion plasmas such as nuclear fusion and space plasmas, as a first stage, effects of the parallel flow velocity shear on the drift wave in two-component ion plasmas are investigated using sodium (Na), potassium (K) and cesium (Cs) as unequal-mass ions.

Experiments are performed in the Q_T-Upgrade machine of Tohoku University. At both the ends of the cylindrical machine, there are tungsten hot plates used as the ion and electron emitter. The ions are generated by contact ionization, and electrons are generated by thermionic electron emission. The ion emitter is concentrically segmented into three sections which can be biased individually. By means of applying different bias voltages between central and peripheral regions (ΔV_{ie}), the parallel ion flow velocity shear can be controlled.

In our experiment, it has been found that the drift wave is excited with increasing the parallel shear strength, and the strength of the parallel shear which makes the fluctuation maximum is different between the cases of each unequal-mass ion plasmas. In addition, the fluctuation amplitude drastically becomes small when the two-component ions are superimposed.

To analyze these experimental results, a theoretical calculation is performed. Figure 1 shows the normalized growth rate (ω_i / ω_r) of an ion acoustic wave as a function of parallel flow velocity shear (ΔV_{ie}) in the two-component ion plasmas calculated by a kinetic dispersion relation. Here the ion acoustic wave is taken up in place of the drift wave for simplicity. Each line corresponds to the change in density ratio between two unequal-mass ions. In the case that the K ion is superimposed on Na ion plasmas, the growth rate of the ion acoustic wave anomalously decreases with increasing the K ion density as shown in Fig. 1(a). When the Na ion is superimposed on K ion plasmas, on the other hand, the parallel shear strength, at which the growth rate has a maximum value, obviously shifts with increasing the Na ion density {Fig. 1(b)}. By taking account of changes in phase velocity of the drift wave and distribution function of each particle (Na ion, K ion, and electron), it is considered that these transition of drift wave is caused by Landau damping of the superimposed ions.

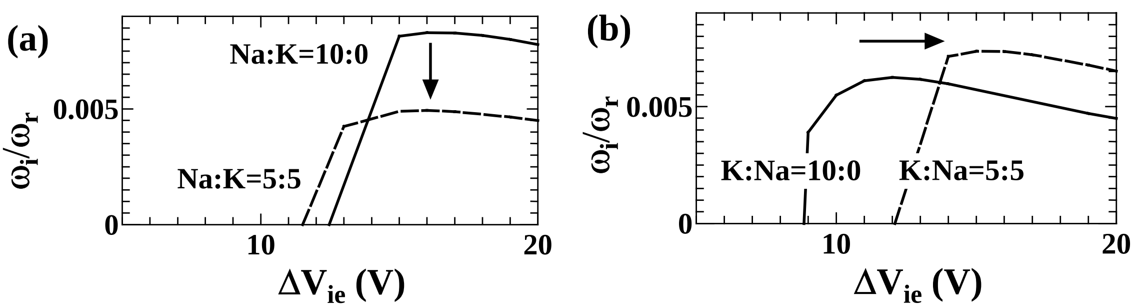

Fig. 1. Normalized growth rate of two-component ion acoustic wave as a function of parallel ion flow velocity shear (ΔV_{ie}). (a) Na ion is superimposed on K ion plasmas, (b) K ion is superimposed on Na ion plasmas.

[1] T. Kaneko, H. Tsunoyama, and R Hatakeyama, Phys. Rev. Let. **90** (2003) 125001.