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Experiments on instabilities driven by sheared magnetic-field-aligned ion flow in negative ion plasmas

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Ionospheric ion-acoustic instabilities observed in situ have been found to stem from the transverse gradient in the velocity of magnetic-field-aligned plasma flow (parallel flow-velocity shear), and the shear-driven/modified ion-acoustic wave was experimentally demonstrated. On the other hand, we have attempted to experimentally study shear-driven drift waves in plasmas to take into account the density gradient which naturally exists in any plasmas. As well as density gradient, the existence of negative ions is of great significance to space plasma research because several kinds of negative ions or dust particles, usually charged negatively, are often components of the space plasmas. We will report experimental observation of how negative ions influence the physical properties of the shear-driven fluctuations.

The experiments were performed using the QT-Upgrade machine where B ˜0.2 T. Potassium ions (K+) are produced through the contact ionization of K vapor on a tungsten (W) plate mounted at one end of the chamber (ion emitter). Electrons are supplied by another W plate at the opposite end (electron emitter). Negative ions, SF6-, are supplied by bleeding an SF6 gas into the K+ - electron plasma and the negative ion exchange fraction (e = n-/n+) can be varied by changing the partial pressure of the gas. The following three factors lead to generating sheared field-aligned K+ flow: 1) The space potential in the plasma is controlled by the bias voltage applied to the electron emitter. 2) The field-aligned-flow velocity of K+ is defined by the potential difference between the ion emitter and the space potential. 3) The ion and electron emitters are each segmented concentrically into three parts, each of which can be biased individually. That is, the K+ flow velocity can individually be controlled in each concentric negative ion plasma layer, thereby generating sheared field-aligned flow at the boundary.

We have observed a low-frequency fluctuation that is unstable only within a certain range of shear strength. This range of shear strength is found to extend to both positive and negative values with increasing negative ion exchange fraction. Moreover, the increase in the negative ion exchange fraction gradually broadens the frequency spectrum of the fluctuation. This is likely to imply that the introduction of negative ions leads the fluctuation to a nonlinear regime. In addition to these results, we will present behavior of wave number vector observed in the negative ion plasma and will give a theoretical model for the instability.