§11. Control of Thermal and Particle Transport by Electrostatic Potential Formation in a Plasma

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The formation and control of electric field in a plasma are very important issues in fusion plasmas. In the confinement-improved mode, suppression of density fluctuations has been often observed to be associated with formation of a rotational shear flow driven by a large radial electric field and its shear [1]. It is necessary, however, to carry out more well-controlled and precisely-measured experiments on this issue. Purpose of the present experiment is to investigate detailed behaviors of low-frequency fluctuations and their relations to the radial electric field or its shear in a wide range of both the electric field and its shear.

The experiment is performed in the Q_T-U device, which has a cylindrical vacuum chamber with 4.5 m in length and 0.2 m in diameter. A plasma with electron density of 10^{10} cm^{-3} and electron temperature of 7 eV is produced by electron cyclotron resonance discharge. A segmented metal endplate which consists of ten concentric rings is set at one end of the cylindrical plasma to precisely control both radial electric field and its shear. By applying various bias voltage independently on each ring of the endplate, the radial electric field and rotation frequency $\omega_{E\times B}/2\pi$ shear are varied in the range of -400 to 300 V/m and 0 to 400 kHz/m, respectively.

Both flute-mode and drift-mode fluctuations appear in the radial region with a steep density gradient. Fluctuation intensities of the flute mode and the drift mode depend sensitively on both radial electric field and its shear. In order to clarify the dependence, we plot the intensities on a 2-D contour map as functions of radial electric field E_r and its shear $\partial\omega_{E\times B}/\partial r$.

Figure 1 (a) and (b) shows the dependence of drift and flute mode intensity, respectively, on both the E_r and its shear plotted on the 2-D contour map. The dark shadow indicates the region where the fluctuations are strongly observed and brighter one indicates the region where the fluctuations are weaker. Broken lines (I), (II), and (III) indicate the level where the shear is equal to the ion diamagnetic drift frequency shear, the level where the characteristics length of shear is equal to the Larmor radius, and the electric field where the $\boldsymbol{E}\times\boldsymbol{B}$ drift frequency equal to a quarter of the electron diamagnetic drift frequency, respectively.

The flute mode are excited only in the region where the shear strength is stronger than that of ion diamagnetic drift frequency and the characteristic length of the shear is less than the ion Larmor radius. It is found that the flute-mode fluctuation is identified as Kelvin-Helmholtz instability which is destabilized by a strong $\boldsymbol{E}\times\boldsymbol{B}$ flow shear.

The drift-mode fluctuation is destabilized in the region of weakly negative electric field, which makes the direction of $\boldsymbol{E}\times\boldsymbol{B}$ drift equal to that of electron diamagnetic drift, and stabilized in the strong E_r region, irrespective of its sign. This observation agree well with theoretical results reported by Chaudhry *et al.*[2] and experimental observation by Mase *et al.*[3].

When the $\boldsymbol{E}\times\boldsymbol{B}$ rotation frequency shear is increased in the case of fixed E_r, the drift-mode fluctuations increase once in a weaker shear region, attain its peak around the shear of ion diamagnetic drift frequency, and then decrease in the stronger shear region. The drift mode is not simply stabilized by increasing the $\boldsymbol{E}\times\boldsymbol{B}$ rotation shear. This behavior suggests that the rotation frequency shear of net ion drift which is determined from both $\boldsymbol{E}\times\boldsymbol{B}$ drift and diamagnetic drift is effective for stabilizing the drift mode fluctuation.

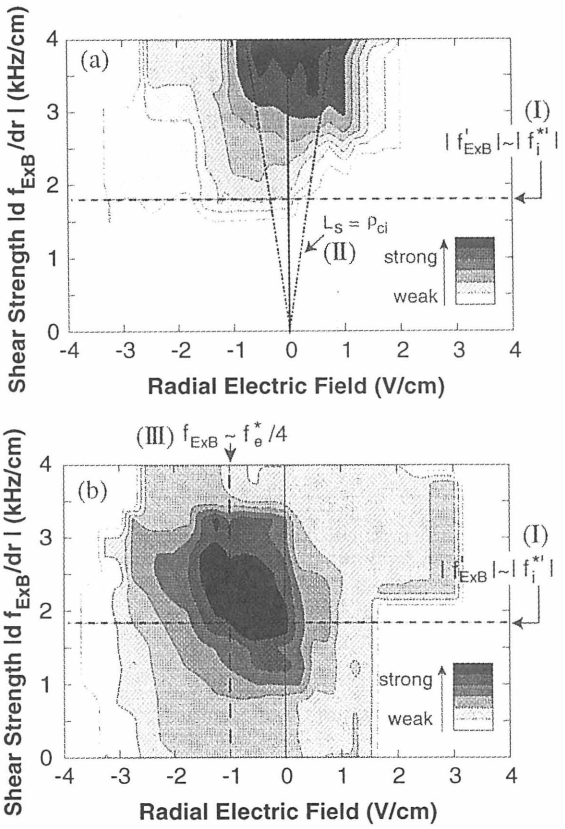

Figure 1: Dependence of (a) flute-mode and (b) drift-mode intensity on both E_r and its shear.

References

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2) M. B. Chaudhry *et al.*, J. Phys. Soc. Jpn. **57**, (1988) 3043.
3) Mase. A *et al.*, Phys. Rev. Lett. **64**, (1990) 2281.