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Excitation and characteristics of externally launched electrostatic ion-cyclotron waves

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Electrostatic ion-cyclotron wave (EICW) has been observed since the 1960s [1]. Strong wave dispersion and damping at harmonics were measured [2]. Since then works on EICWs and ion-cyclotron instabilities have been carried out worldwide [3]. In the presence of a uniform magnetic field, the EICW is characterized as a dispersive wave propagating almost perpendicular to the magnetic field with a frequency near the ion cyclotron frequency. This kind of wave is of great importance in the fields such as the heating of fusion plasmas, basic collective wave experiments, and space plasmas. Previous experiments were performed mostly in current-carrying Q-machines [3] with a narrow plasma column, in which the wave was driven via the internal instability due to electron drift parallel to the magnetic field. Only a few experiments were performed using external (antenna) driving [2] that enables the measurement of dispersion relation. In order to further study the characteristics of the EICWs, it is of great necessity to excite the wave in a larger transverse scale and by different methods.

Here, we report our EICW excitation experiment performed in a steady magnetic mirror. The wave was launched via a grid situated at the center of the mirror whose normal direction was perpendicular to the magnetic field. The plasma had a larger transverse space for the observation of the wave evolution compared with that of the Q-machines. Besides, the frequency of the excited waves can be varied over three times the ion cyclotron frequency so that both fundamental and harmonic modes of the EICWs can be observed.

Ar plasma was generated by hot-cathode discharge near one coil region and diffused into the mirror. The excitation grid (EG, 80 mm in diameter) was negatively biased and applied with either a continuous or a pulsed driving voltage so that either continuous or pulsed waves were launched (Fig. 1). A moveable ring-shaped probe was used to diagnose the plasma parameters and receive the wave signals. Both the phase and group velocities of the wave signals can be obtained by time-of-flight (TOF) method. The dispersion relations of the fundamental and the harmonic modes were measured, according to which the EICW signals were identified.

It was shown that when the driving frequency is near the ion cyclotron frequency, both the fluid and the kinetic dispersion relations were in good agreement with the experiment data (Fig. 2). However, when the driving frequency increases to near the second and third harmonics of the ion cyclotron frequency, the fluid result failed to explain the experimental data but the kinetic theory still did. Moreover, the dependence of the measured phase and group velocities on the magnetic field was shown to be in agreement only in a limited range with the fluid model, indicating the limitations of the fluid theory, which needs further investigations.

References
[1] R. W. Motley and N. D'Angelo, Phys. Fluids **6**, 296 (1963).
[2] T. Ohnuma, *et al*, Phys. Rev. Lett. **26**, 541 (1971).
[3] J. J. Rasmussen and R. W. Schrittwieser, IEEE Trans. Plasma Sci. **19**, 457 (1991).

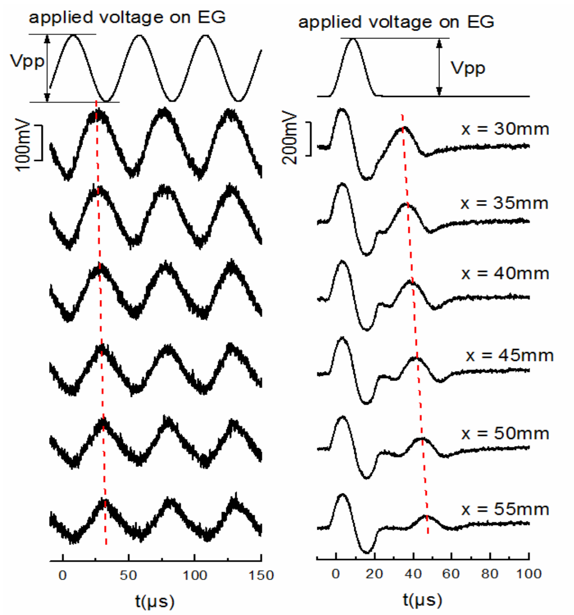

Fig.1 Evolution of the received wave signals (continuous and pulse) with respect to the distance from the exciter.

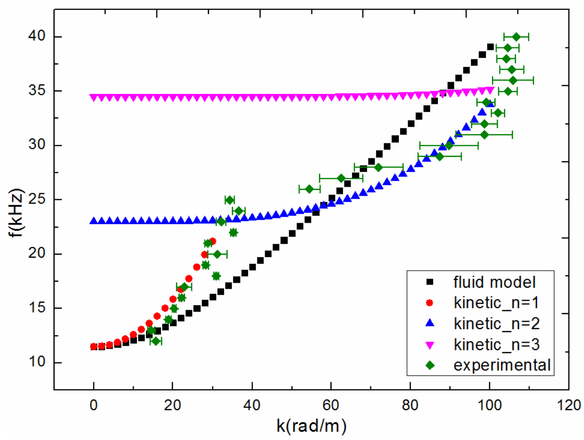

Fig. 2 Comparison of the measured dispersion relation with that from theoretical models. The ion cyclotron frequency is 11.5 kHz.