§7. Excitation of RF Waves in GAMMA 10 and in the Local Magnetic Mirror Configuration on LHD

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In the GAMMA 10 tandem mirror, the ion cyclotron range of frequency (ICRF) heating is used not only for producing initial plasma but also for sustaining MHD stability and heating of the central cell ions. A hot-ion mode of operation has been realized and plasmas with a strong temperature anisotropy (which is defined as the temperature ratio of perpendicular to parallel to the magnetic field line) are formed. In the typical discharges, the anisotropy becomes more than 10 and Alfvén ion cyclotron (AIC) modes are spontaneously excited due to the anisotropy [1]. The AIC mode is one of the micro-instabilities and is observed as an eigenmode in the axial direction.

On the while, in fusion-oriented devices with a toroidal configuration, a high power ICRF heating and a high power neutral beam injection (NBI) heating are commonly used to create the high performance plasmas. Resultant high-energy ions are trapped in the local magnetic mirror configuration and form the velocity distribution with the strong anisotropy. In LHD, the measurement of fluctuations in the ion cyclotron frequency range has been started. In burning plasmas, the ion cyclotron emission (ICE) has been observed in the ion cyclotron frequency and its higher harmonic regions [2].

In this research, the mechanism of the excitation of those micro-instabilities in the ion cyclotron frequency range is investigated and the relation among the AIC mode, ICE and other instabilities. On 2004, the experimental observation is focused to the excitation of the higher harmonic AIC waves in GAMMA 10. Figure 1 shows the temporal evolution of the frequency of excited modes and the wave amplitude is represented by a shade of brightness. The fundamental AIC waves are shown in Fig.1(a) and the fluctuations in the 2nd harmonic region in Fig.1(b). The frequency changes depending on the plasma parameters are clearly observed in both signals.

To evaluate the excitation of the higher harmonic waves, the dispersion relation of the electromagnetic waves in hot plasmas with the temperature anisotropy has been solved. It is verified the waves in a fast Alfvén wave branch become unstable due to the temperature anisotropy. As shown in Fig.1, the frequency band of the 2nd harmonic waves is narrower than that of the fundamental waves. In Fig.2, the growth rate of the 2nd harmonics is plotted as a function of the ion temperature. The growth rate of the 2nd harmonic waves is indicated to be quite small in the present plasma parameters.

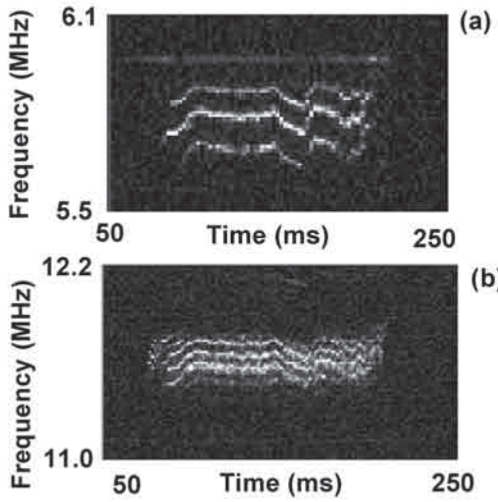

Fig.1 Temporal evolution of the frequency of excited modes (a) AIC modes and (b) 2nd harmonic waves. The wave amplitude is represented by a shade of brightness.

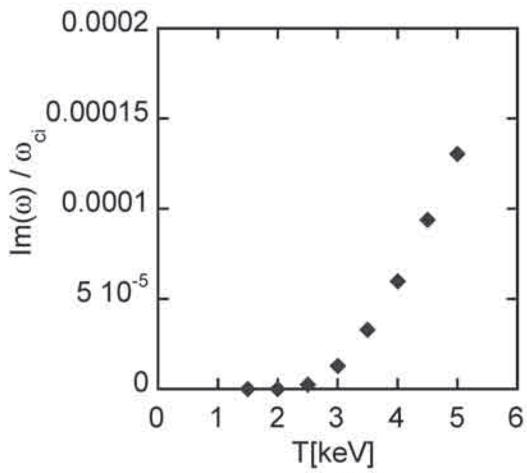

Fig.2 The growth rate of the 2nd harmonic waves are plotted as a function of ion temperature

[1] Ichimura, M., et al., Phys. Rev. Lett. **70**, 2734 (1993).
[2] Cottrell, G.A. and Dendy, R.O., Phys. Rev. Lett. **60**, 33 (1988).