§6. Spontaneous Excitation of Ion Cyclotron Range of Frequency Waves in GAMMA 10

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In magnetically confined plasmas, spontaneously excited waves in the ion cyclotron range of frequency (ICRF) will be driven due to the presence of non-thermal ion distribution and a temperature anisotropy. In a typical discharge on the GAMMA 10 tandem mirror, Alfvén-ion-cyclotron (AIC) modes are spontaneously excited due to the strong temperature anisotropy. In D-D fusion plasma experiments on JT-60U, ion cyclotron emissions (ICEs) have been observed [1] and the possible mechanism for ICE has been considered to be the excitation of magnetoacoustic waves near the outermost magnetic surface [2]. In the low frequency region, so-called global Alfvén Eigenmodes (GAE) have been observed in many toroidal devices. We have also reported the observation of Alfvén Eigenmodes (0.5 ~ 2.5 MHz) in LHD [3]. In this report, low frequency magnetic fluctuations observed in GAMMA 10 are described.

ICRF waves are used for the plasma production and heating in GAMMA 10. Ion temperature in the range of several keV has been achieved in the relatively low density of around $2x10^{18}$ m^{-3}. In high power ICRF experiments, plasmas with a strong temperature anisotropy are produced when the cyclotron resonance layer exists near the midplane of the central cell. Saturation of the diamagnetism is sometimes observed in the experiments with increasing heating power. In such high temperature plasmas with the strong anisotropy, the AIC modes are excited spontaneously, and moreover, low frequency (LF) waves which have differential frequencies between the heating waves (6.36 MHz) and the AIC modes (5.5 – 6.0 MHz) are detected, as shown in Fig.1. The parametric decay of the heating waves to the AIC modes and the LF waves is one of the possible mechanisms for the saturation. By using two magnetic probes, azimuthal mode structures are measured at the midplane of the central cell. The heating waves of m = +1 or +2 and the AIC modes of m = -1 are detected. Because the fundamental resonance layer exists between the location of ICRF antenna and magnetic probes, the slow Alfvén waves of m = -1 and/or m = 0 will be damped and only fast Alfvén waves of m = +1 can propagate to the probe location. The AIC modes are always detected as m = -1 as observed in the previous experiments. As shown in Fig.2, the LF modes with different azimuthal structures (m = 0 and +1, sometimes +2) are detected. These experimental observations suggest the heating ICRF waves with different azimuthal mode numbers branch into the AIC modes and the LF waves. Two magnetic probes are also installed in the axial direction (z = 0.33 m and 1.11 m). As reported in the previous experiments, the AIC modes have a standing wave structure in the axial direction. The wavelength of the standing waves is not determined from the present probe location.

[1] Ichimura, M., et al., Nuclear Fusion 48 035012 (2008)
[2] Dendy, R.O., et al., Nuclear Fusion 35 1733-42 (1995)
[3] Higaki, H., et al., Plasma Fusion Res., 1, 034 (2006)

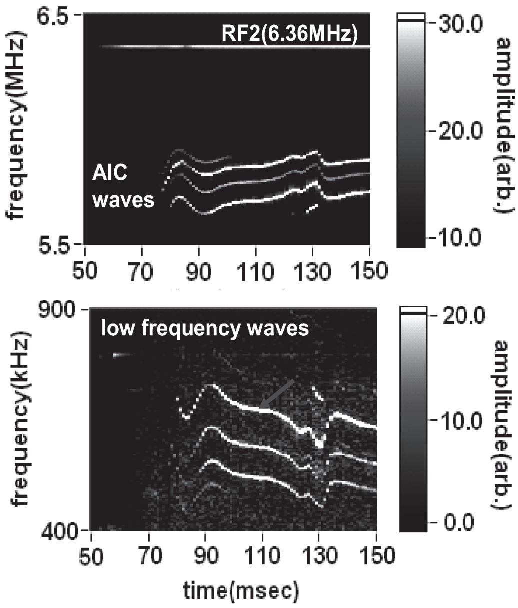

Fig.1 Frequency spectra of AIC-modes (upper figure) and low frequency waves which have differential frequencies between the heating wave (6.36 MHz) and the AIC-modes (lower figure).

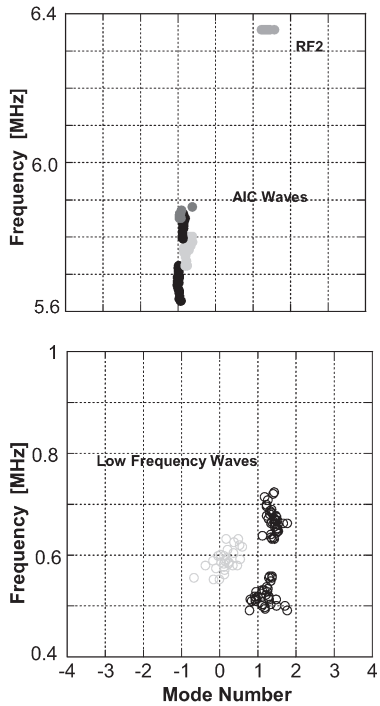

Fig.2 Azimuthal mode structures of the heating wave, the AIC modes (upper) and the LF waves (lower).