§3. Correlation between ICRF Waves and Behavior of High Energy Ions on GAMMA 10

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The ion cyclotron range of frequency (ICRF) waves have been used for the plasma production and heating in the GAMMA 10 tandem mirror. Plasmas, of which temperature is above 10keV, have been produced and sustained stably. The temperature anisotropy becomes more than 10. Owing to such strong anisotropy, Alfvén ion cyclotron (AIC) waves are excited spontaneously. The wave-wave couplings between ICRF waves and the AIC waves are observed and parametric decay of the heating ICRF waves is one of the candidates.

In 2011, a micro-wave reflectometer system for the measurement of density fluctuations has been used to evaluate the behavior of the AIC waves in the core region [1,2]. An array of micro-wave horns is set inside vacuum vessel of the central cell. When the power of heating ICRF is increased, the diamagnetism increases and the temperature anisotropy becomes strong. Density fluctuations of electromagnetic waves in ICRF have been discussed [3] and detected in GAMMA 10 [4]. An axial structure is measured with horn antenna array installed in the vacuum chamber and a radial structure is measured by changing the frequency of injecting microwave. Figure 1 shows the temporal evolution of (a) plasma parameters and (b)-(d) intensity plots of frequency spectra of inner density fluctuations. As indicated in the figure, f_{RF1E}, f_{RF1W}, f_{RF2} and f_{AIC} are frequencies of ICRF waves for plasma production (RF1-East and RF1-West of 9.9 and 10.3 MHz), ICRF wave for heating (RF2 of 6.36 MHz) and excited AIC waves (just below that of RF2), respectively. Several couplings between injected ICRF waves and the AIC waves are observed from low frequency to high frequency regions. Couplings in the range more than 20 MHz are identified. Parametric decay from the heating ICRF waves to the AIC waves and low-frequency waves of which frequencies are $f_{RF2} - f_{AIC}$ has been discussed. Continuous density fluctuations are detected in the range lower than 0.1 MHz as shown in Fig.1(d). In the region around 0.1 MHz, fluctuations of which frequencies are differential frequencies between discrete peaks of the AIC waves (indicated as $f_{AICn} - f_{AICn-1}$) are excited. As described in the following section, these low-frequency waves around 0.1 MHz are clearly detected with electrostatic probes installed in the periphery region.

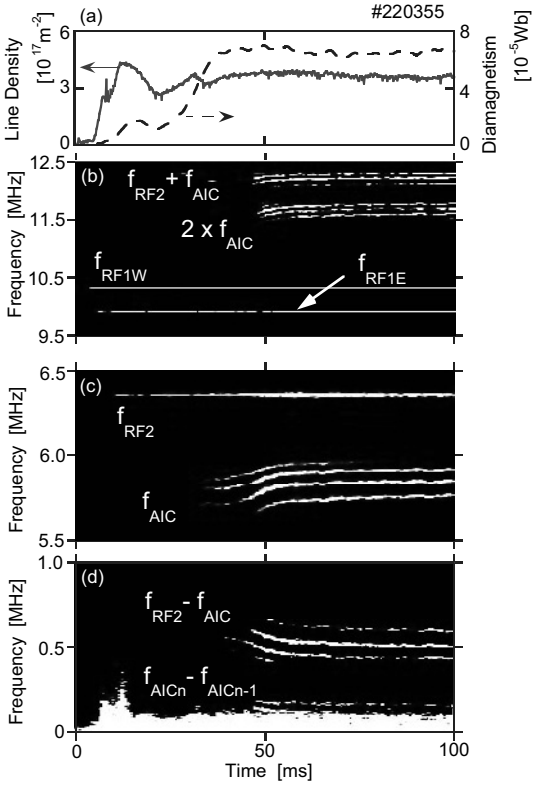

Fig.1 Temporal evolution of (a) line density and diamagnetism, and density fluctuations in the range of (b) 9.5-12.5MHz (c) 5.5-6.5MHz and (d) 0-1.0 MHz.

Low-frequency magnetic fluctuations around 0.1 MHz, of which frequencies are differential frequencies between discrete peaks of the AIC waves, are clearly detected in the ion saturation current signal measured with electrostatic probes. To evaluate behaviors of high-energy ions, a semiconductor detector is installed in the east end (eeHED) for ions escaped along the magnetic field line. Figure 2 shows (a) the raw signal of eeHED and (b) the intensity plot of the frequency spectrum of the eeHED signal. The fluctuations around 0.1 MHz are clearly detected. Pitch angle scattering in the velocity space owing to spontaneously excited Alfvén wave are indicated [5].

[1] R. Ikezoe, et al., Plasma Fusion Res., 6 (2011) 2402047.
[2] R. Ikezoe, et al., Plasma Conference 2011, 2011.11.23, Kanazawa, 23P087
[3] H. Hojo, et al., J. Plasma Fusion Res., 69 (1993) 1043.
[4] A. Mase, et al., Phys. Fluids B, 5 (1993) 1677.
[5] M. Ichimura et al., Plasma Conference 2011, 2011.11.23, Kanazawa, 23P090.

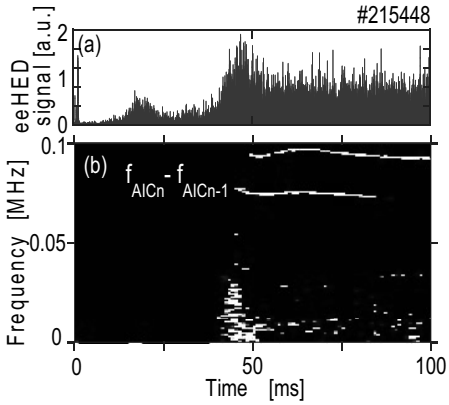

Fig.2 Phase differences between density fluctuations measured by an electro-static probe and fluctuations in ccHED signals..