§7. 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. High-energy ions are measured at the midplane of the central cell and at the east end to study wave-particle interactions with excited waves. The transport of ions due to fluctuations in the perpendicular and parallel directions is studied.

In 2010, a micro-wave reflectometer system for the measurement of density fluctuations has been newly installed to evaluate the behavior of the AIC waves in the core region[1-3]. An array of micro-wave horns is set inside vacuum vessel of the central cell. Figure 1 shows the intensity plot of temporal evolution of the frequency spectra of (a) magnetic probe signal in the peripheral region and (b) micro-wave reflectometer signal in the core region. As shown in the figure, the same frequency peaks are observed in both signals of magnetic fluctuation and density fluctuation. There is strong coherency between both signals. By changing the frequency of the incident micro-wave and using the array of horns in the magnetic field direction, temporal and spatial behaviors of the AIC waves in the core region are measured.

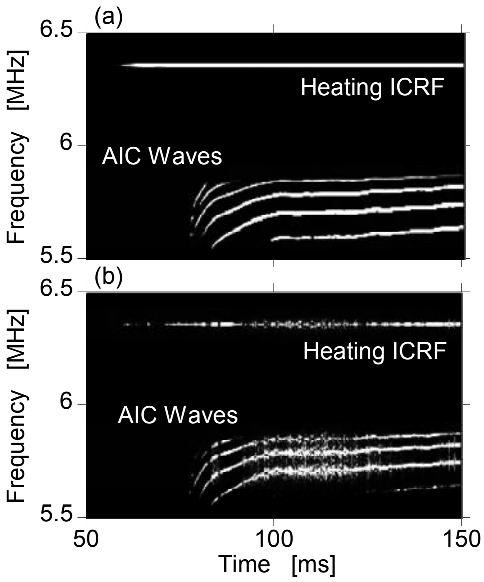

Fig.1 Intensity plot of temporal evolution of the frequency spectra of (a) magnetic probe signal in the peripheral region and (b) micro-wave reflectometer signal in the core region.

Pitch angle scattering of ions from perpendicular to parallel directions caused by the AIC waves are clearly detected at the east end with a high-energy ion detector (eeHED). On the other hand, high-energy ions are also detected at the location outside the limiter radius in the central cell. Fluctuations, of which frequencies are the same as those of drift-type fluctuations, are clearly observed in the signal of central-cell high energy ion detector (ccHED). ccHED can measure the pitch angle distribution of high-energy ions at the midplane of the central cell. To clarify the radial transport of high-energy ions caused by fluctuations at their turning points, the pitch angle dependence of the interaction between fluctuations and high-energy ions is analyzed. Figure 2 shows the phase differences between density fluctuations detected by an electro-static probe and fluctuations in high-energy ion signal measured by ccHED as a function of the turning point of high-energy ions. Pitch angles of 85, 75 and 65 degrees correspond to turning points of z = 0.7, z = 1.5 and z = 1.9 m, respectively. The pitch angle dependence of the phase difference is clearly observed. When the pitch angle is 90 degrees, the phase difference is defined as zero because ccHED is located just at the midplane of the central cell. The axial wave number of the drift-type fluctuation in this experiment is estimated to exist between 0.8 and 1.38 m^{-1}. As shown in the figure, measured phase differences exist between them and it will be possible to consider that hot ions interact with those fluctuations near the turning points[4-6].

1) R. Ikezoe, et al., The 5th Japan-Korea Seminar on Advanced Diagnostics for Steady-State Fusion Plasma.
2) R. Ikezoe, et al., 20th International Toki Conference.
3) R. Ikezoe, et al., 27th Annual Meeting of JSPF, Hokkaido Univ., Nov.30, 2010, 30pC07
4) Y. Imai, et al., 20th International Toki Conference.
5) Y. Imai, et al., 27th Annual Meeting of JSPF, Hokkaido Univ., Dec.2nd, 2010, 02P874P
6) M. Ichimura, et al., 8th Int. Conf. on Open Magnetic Systems for Plasma Confinement, Novosibirsk, 2010.

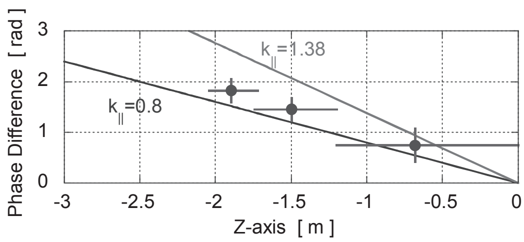

Fig.2 Phase differences between density fluctuations measured by an electro-static probe and fluctuations in ccHED signals. Pitch angles of ions correspond to their turning points in the magnetic mirror field.