§21. Spontaneously Excited ICRF Waves and Axial Energy Transport on GAMMA 10

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It is an important issue for magnetic confinement of energetic ions to expand an understanding of wave-particle interaction causing ion transport. As a result of one of such interactions, axial transport of mirror-confined energetic ions has been observed in the GAMMA 10 tandem mirror, where Alfvén-ion-cyclotron (AIC) waves are spontaneously excited due to strong anisotropy of ion temperature and cause relaxation of the anisotropy.

By making use of the open-field structure, at the GAMMA 10 east end, we directory investigated the detailed behavior of the energetic ions which were axially transported along the magnetic field lines from the main confinement region called central cell. Figure 1(a) shows the raw signal of the energetic-ion flux at the machine end, which were measured by using a semiconductor detector with aluminum-coated surface; the detectable minimum energy is restricted to about 6 keV. Since the obtained signal is well pile-upped, its intensity corresponds to the amount of detected ions. As shown in Fig. 1(a), its intensity rapidly increases from 40 ms, when the AIC waves are spontaneously excited in the central cell. This implies the AIC waves have some effect on the axial transport of energetic ions. Furthermore, the detailed time evolution of the pile-upped signal demonstrates a periodic burst-like loss of energetic ions, of which spectrum is shown in Fig. 1(b). The periodicity of the burst-like loss is dominated by 70 – 100 kHz, which are the exact difference frequencies of the simultaneously excited AIC waves. Non-linearly excited waves including those having the difference frequencies of the AIC waves were clearly observed in the central cell by using a reflectometer (see Fig. 2(b)).

The reflectometer adds different valuable information; the nonlinear coupling which produces waves such as those associated with the axial transport described above are enhanced rapidly just after the saturation of the plasma pressure as shown in Fig. 2. This observation suggests two possible causes of the saturation of the plasma pressure. One is the axial loss of energetic ions due to the excited waves of 70 – 100 kHz. The other is a parametric decay of the heating ICRF power; its energy is transferred to the low-frequency waves of 400 – 700 kHz through the coupling with the AIC waves. The frequency of the heating ICRF wave is 6.36 MHz and 400 – 700 kHz are the difference between 6.36 MHz and the frequencies of the AIC waves, 5.6 – 6 MHz. The quantitative characterization of these effects on the saturation of the plasma pressure is under investigation.

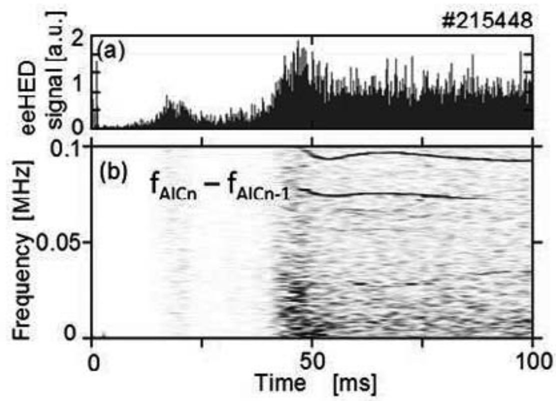

Fig. 1. Temporal behavior of the axially transported energetic-ion flux measured at the GAMMA 10 east end. (a) and (b) are the raw signal and its frequency spectrum, respectively.

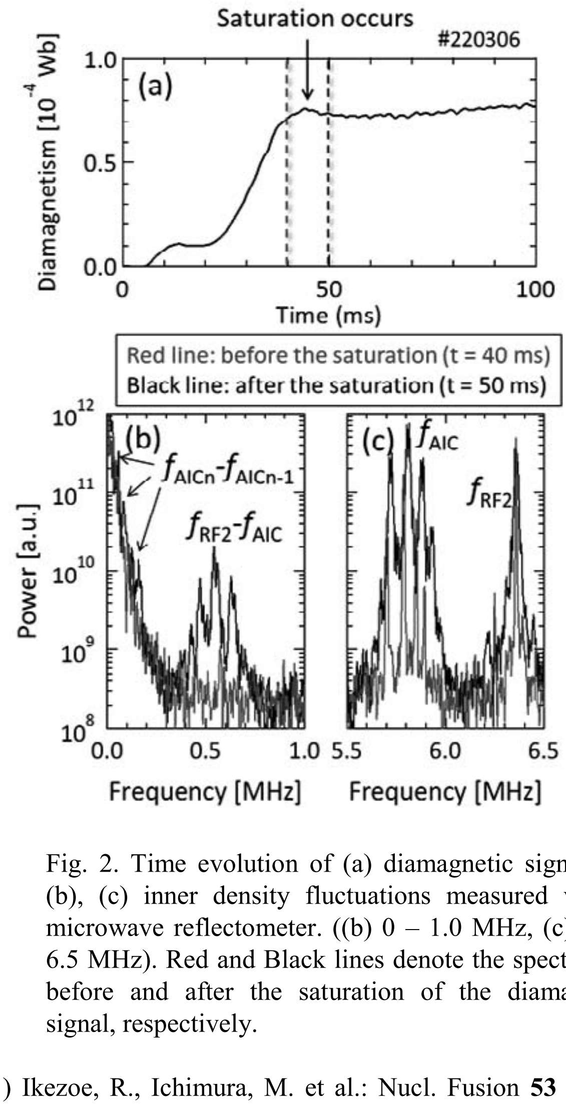

Fig. 2. Time evolution of (a) diamagnetic signal and (b), (c) inner density fluctuations measured with a microwave reflectometer. ((b) 0 – 1.0 MHz, (c) 5.5 – 6.5 MHz). Red and Black lines denote the spectrum at before and after the saturation of the diamagnetic signal, respectively.

1) Ikezoe, R., Ichimura, M. et al.: Nucl. Fusion **53** (2013) 073040.
2) Ichimura, M. et al.: Transactions of Fusion Science and Technology **63**, No. 1T (2013) 115.