§78. Study on Production of Energetic Ions in ECH/ECCD Plasmas in LHD

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In some torus devices, tail ion has been observed only in the ECH/ECCD plasmas. These phenomena have been considered to be due to the anomalous electron-ion coupling or acceleration by LH-decay waves, however, the mechanism of the ion tail formation is still an open question.

In the 70 GHz 2nd harmonic ECH plasmas of Heliotron J, the energetic ions has been observed under the low density conditions below than 1×10^{19} m^{-3}. The apparent tail temperature increases with decreasing the density. It is also found that the slope of the ion tail becomes large with the ECH injection power. In the 53 GHz ECCD plasmas of CHS, the energetic ions have been formed when the electron density was below than 0.5×10^{19} m^{-3} and the toroidal plasma current was higher than 3.8 kA. Under the conditions, several modes of n=1 and a mode of m/n=5/2 having the frequency range from 50 kHz to 200 kHz has appeared. These modes have propagated in the ion diamagnetic drift direction and in the counter direction of the magnetic field. In these experiments, unfortunately, the plasma production and heating was done only by one ECH system.

In the LHD device, four ECH systems have been installed and various heating experiments, for example additional heating, modulation or current drive, can be performed. Figure 1 shows a typical time evolution of the averaged electron density and ion energy distribution in ECH plasmas (4 Units, 84GHz, 82.7GHz, 1MW). In the earlier phase of the discharge where the electron density was around 0.1×10^{19} m^{-3}, the flux of the tail ion was observed in the energy more than 20 keV. The ion energy distribution was measured with compact NPA system. The apparent tail temperature, estimated from the slope of the energy spectrum as shown in Fig. 2, was found to be about 3 to 4 keV. The slope of the energy distribution did not depend on the electron density. Figure 3 shows the dependence of the apparent temperature and amount of the tail flux on the electron density. The obtained tail temperature was in the range from 2.5 to 5 keV and it was insensitive to the electron density, while the amount of the ion flux decreased rapidly as increasing the density. No coherent mode was observed like that obtained in CHS.

In the next experimental campaign, the ion energy distribution in the lower energy side (< 10keV) will be measured and compared with the bulk ion. The measurements of the high frequency wave will be tried in order to investigate the mechanism of the ion acceleration.

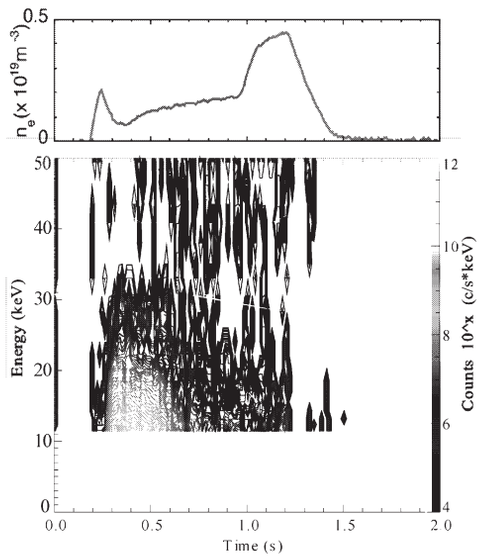

Fig. 1. Time evolution of electron density and ion flux measured with compact NPA in ECH plasmas of LHD.

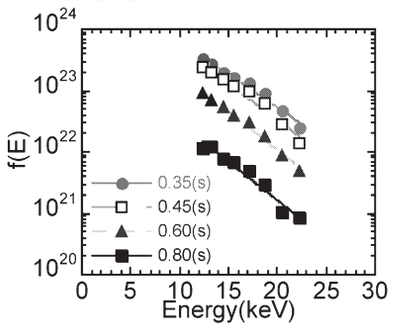

Fig. 2. Ion energy spectrum in ECH plasma.

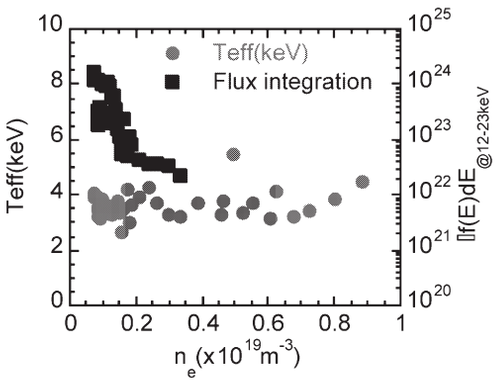

Fig. 3. Dependence of the apparent temperature of tail ion and amount of the tail flux on the electron density.