§52. Experimental Study of Fast Ion Excitation in High Power ECH Plasmas

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Formation of the ion tail has been observed in several torus devices even in the electron heated plasmas such as ECH [1,2]. To interpret the phenomena, two models have been proposed. One is the anomalous electron-ion coupling in the slide-away regime of the suprathermal electrons. Then, the formation of the suprathermal electrons and the relation to the ion tail formation are the key points to understand the physics. The other is the acceleration by LH waves excited by the parametric decay wave processes. In this case, injection the X-mode waves from the high field side (HFS) is required to access UHR layer. In the previous work, we have observed the ion tail formation both in the HFS injection and 2nd harmonic ECH discharges. In this study, we analyzed the results of the tail formation obtained in LHD and compared with other devices.

Figure 1 shows the ion energy spectrum obtained in the fundamental (B_t=2.9T) and the 2nd harmonic (B_t=1.35T) ECH plasmas of LHD (R_{ax}=3.53m). The ion tail both in the two cases was formed when the electron density was lower than $0.1\text{x}10^{19}\text{m}^{-3}$. In the 2nd harmonic ECH plasmas, the tail formation depended sensitively on the ECH injection angle. In the case that the ECH injection angle was set to be R_{MID}=3.58m, where it was slightly outside of the plasma axis, the tail temperature was higher than the other two cases (R_{MID}=3.48 and 3.53m). The tail temperature was determined by the slope of the spectrum in the energy from 3 to 10 keV. The tail temperature of R_{MID}=3.58m was almost the same as that of the fundamental ECH plasmas, while the bulk (1 keV < E < 3 keV) temperature was lower than that of the fundamental ECH case. The effect of the ECH injection methods or the ion confinement dependence on the magnetic field strength should be taken into account to interpret the phenomena.

Figure 2 shows the tail and bulk temperature obtained in the fundamental ECH plasmas as a function of the line-averaged electron density. In the density range of $0.02\text{~}0.065\text{x}10^{19}\text{m}^{-3}$, the tail temperature decreased as increasing the density. The difference between the bulk and tail temperature was small in the case of the density more than $0.065\text{x}10^{19}\text{m}^{-3}$ and the bulk temperature was slightly increased with the density. The tendency is similar to that obtained in Heliotron J and CHS [2]. The fraction of the tail component, defined by $\int E\, f_{\mathrm{Tail}}(E)\, \mathrm{d}E \,/ \int E\, f(E)\, \mathrm{d}E$, is shown in Fig. 3 as a function of the ECH power normalized by the total electron numbers (line-averaged electron density times plasma volume, $\bar{n}_e V_p$), where $f(E)$ is the ion distribution function and the subscript "Tail" means the ion tail component. Therefore, the horizontal axis shows the heating power per particle and the vertical axis is the fraction of the stored energy of the hydrogen tail ions to the total one. The tail component obtained in CHS and Heliotron J is also shown in the figure. Note that the tail component increases with the normalized ECH power in the three devices and the slope is proportional to $(P_{ECH}/\bar{n}_e V_p)^{0.74}$. Although the further analysis should be needed to understand the physical mechanism, the slope may represent the efficiency of the tail ion formation by the high power ECH.

1) V.Erckmann and U.Gasparino, Plasma Phys. Control. Fusion **36** (1994) 1896.
2) S. KOBAYASHI,. *et al*. Proc 17th ITC (2007) P2-071.

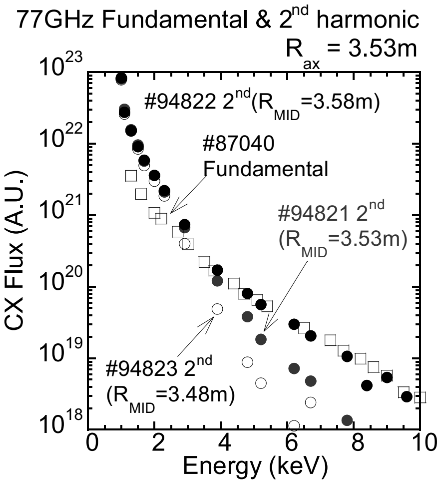

Fig. 1. Ion energy spectrum obtained in fundamental and 2nd harmonic ECH plasmas of LHD.

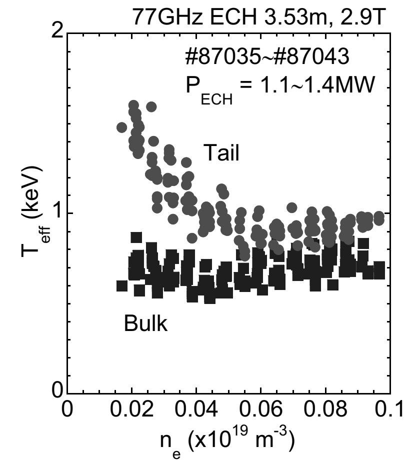

Fig. 2. Bulk and tail temperature of hydrogen ion as a function of electron density obtained in 77GHz ECH plasmas of LHD.

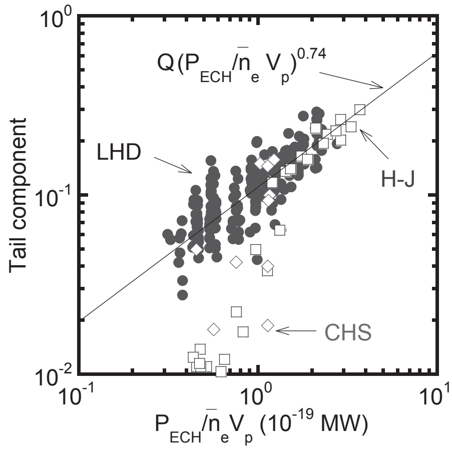

Fig. 3. Fraction of the tail component as a function of ECH power normalized by the total electron numbers.