

§43. Experimental Study of Ion Tail Formation by High Power ECH

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In several torus devices, ion tail formation has been observed even in the electron heated plasmas by ECH¹⁾. These phenomena have been considered to be due to the (1) anomalous electron-ion coupling in the slide-away regime of the superthermal electron or (2) acceleration by LH waves excited by the parametric decay wave processes. In this experimental campaign, high power 77GHz ECH systems have been newly installed in LHD. The possibility of the formation of tail ions by the ECH high power injection and its physical mechanism are examined.

Figure 1 shows the typical time evolutions of the (a) ECH power, (b) stored energy, electron density and H α -line intensity, (c) charge exchange (CX) flux measured with the E//B-NPA system, (d) effective ion temperature and (e) power density spectrum of magnetic probe data obtained in the ECH plasmas of LHD, respectively (#87040, $R_{ax}=3.53m$, $B_t=+2.907T$, $\gamma=1.254$, $B_q=100\%$). The ECH microwaves were launched from low magnetic field side and total power was at 1.38MW. After the injection of 77GHz ECH (9.5U; 0.62MW), the high energy CX flux above 5keV increased quickly as compared with the increasing rate of the stored energy or the electron density. In that case, the response for the bulk CX flux ($E=1.6keV$) to the turned-on of 77GHz ECH was smaller

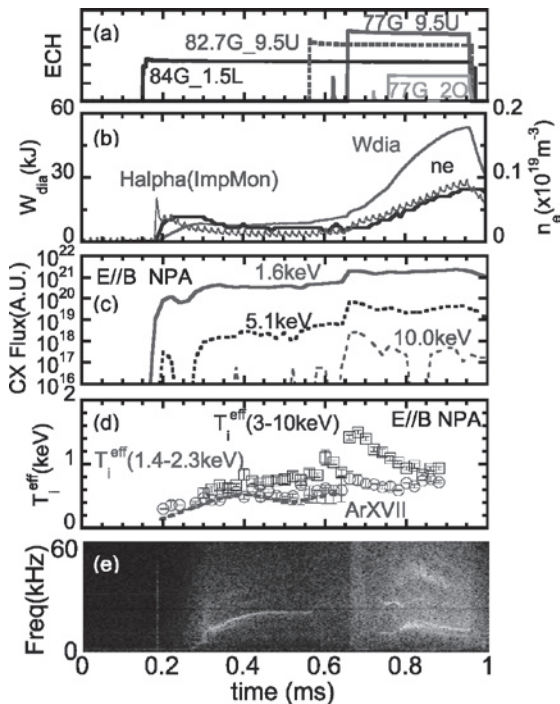


Fig. 1. Time evolution of the plasma parameters obtained in ECH plasmas of LHD.

than those of tail components, which implies an increase in the effective ion temperature. The comparison of the energy spectrum before and after the 77GHz ECH launch is shown in Fig. 2. After the 77GHz ECH launch, a “folding” of the energy spectrum around 3keV was clearly observed, indicating a formation of ion tail. The effective temperature (T_i^{eff}) for tail in the energy range from 3 to 10keV, as shown in Fig. 1(d), increased from 1 to 1.5 keV after the 77GHz ECH launch, while the change in T_i^{eff} for bulk (1.4 to 2.3keV) was not so significant. Note that the time evolution of the ArXVII temperature from crystal spectrometer was almost similar to that of the bulk T_i^{eff} . After the launch of 77GHz ECH, the effective tail temperature gradually decreased as increasing density. The increase in T_i^{eff} was small after the injection of 77GHz ECH (20), which may be due to the smaller power (0.29MW) than the former 77GHz system (9.5U). Magnetic fluctuations around 10-30kHz was observed as shown in Fig. 1(e). Although the driving mechanism is not clear, the drift motion of the trapped energetic electrons may cause the MHD instability. A similar magnetic fluctuation has also been observed in the 2nd harmonic ECH plasmas in LHD and CHS.

As shown in Fig. 3, the tail temperature is highly sensitive to the ECH power density (ECH power normalized by the line-averaged electron density and plasma volume), while the bulk one is almost constant to the normalized power, which indicates the formation of the tail ions depends on the ECH power density. In these discharges, the superthermal electrons were observed by PHA. Since the one-path absorption fraction of ECH microwave was low under the density condition, the effect of the microwave absorption from the high field side due to the multi-reflection is not clear and the formation mechanism of tail ions due to the excitation of the LH waves by the parametric decay wave processes is still obscure. In the next experimental campaign, we will verify the tail ion formation in the 2nd harmonic ECH plasmas under the condition which the effect of the LH mode conversion would be negligible.

1) S. KOBAYASHI, *et al.* Proc 17th ITC (2007) P2-071.

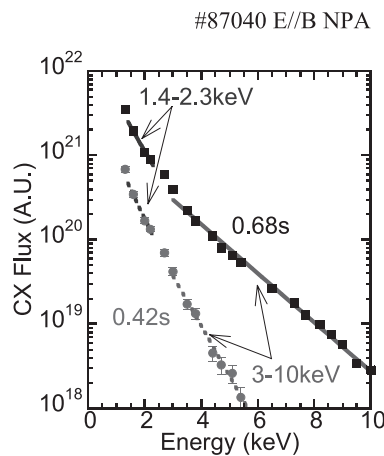


Fig. 2 Energy spectrum of CX neutrals before and after 77GHz ECH launch.

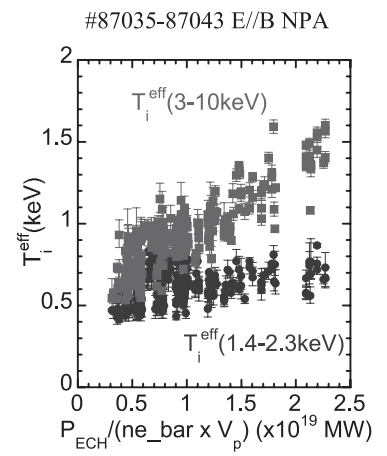


Fig. 3 Dependence of bulk and tail effective temperature on ECH power density.