§23. High Time-resolved Fast Ion Measurements Affected by Fast-ion-driven MHD Activity

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In magnetically confined plasmas, it is important subject to estimate the spatial- and velocity-distribution of fast ions because it is strongly linked to the fast-ion-induced MHD instabilities. Since the MHD instabilities are the physical phenomena having fast time response, a high time-resolved measurements for the fast ions are indispensable to clarify the wave-particle interactions. We have developed the high time-resolved fast ion measurements with a Si-semiconductor based detector and have applied in LHD and Heliotron J plasmas [1,2]. In this study, we report on the ion cyclotron emission measured in the MHD activities due to Energetic particle driven InterChange mode (EIC).

The energetic particle driven EIC has been observed in high-T_i discharge experiments of LHD (see Fig. 1). In this case, the EIC bursts observed during perpendicular neutral beam (#4B, #5) injection. A significant RF radiation in the frequency range of several MHz – 70 MHz was observed by one-turn loop antenna in the high-T_i plasmas of LHD [3]. Since the magnetic field strength was 2.85T in the case, the observed RF radiation is considered as the ion cyclotron emission (ICE). It has been found that the intensity of RF radiation increased with the perpendicular neutral beam injection. The EIC burst induced by the trapped fast ions injected by perpendicular NB affects the velocity distribution of fast ions due to its radial transport. The excitation of ICE is expected because of the distortion of the fast ion velocity distribution. The H_α emission intensity and the electron temperature measured by ECE responded to the EIC bursts. As shown in Fig. 2, a slightly change in the electron density was observed at the timing of the EIC burst. The increase in the ECE electron temperature due to the EIC burst propagated from the core region to the edge region. Then the change in the bulk plasma profile should be taken into account to discuss the fast ion transport due to EIC.

In order to observe the rapid response of the velocity and spatial distribution of fast ion due to bursting modes such as EIC in the deuterium experiment phase, a spectroscopic technique for the fast ion measurement such as Fast Ion D-alpha (FIDA) diagnostic should be developed for the LHD plasmas. The fast ion diagnostic based on a Si-semiconductor detector has been installed and tested in the Heliotron J NBI plasmas by the bi-directional collaboration research program [2]. An inter-machine comparison of the fast ion transport due to the MHD activity can contribute to the understanding of the physical mechanism and the development of the control scenario of the fast-ion induced MHD activity.

1) M. Osakabe, et al., Plasma and Fusion Research **5**, S2042 (2010).
2) M. Yasueda, et al., Plasma Conference 2014 Nov.18-21, 2014, Niigata, 19PB-062.
3) K. Saito, et al., Plasma Science and Technology, **15**, 209 (2013).

#128705, R_{ax}=3.6m, B_t=2.85T

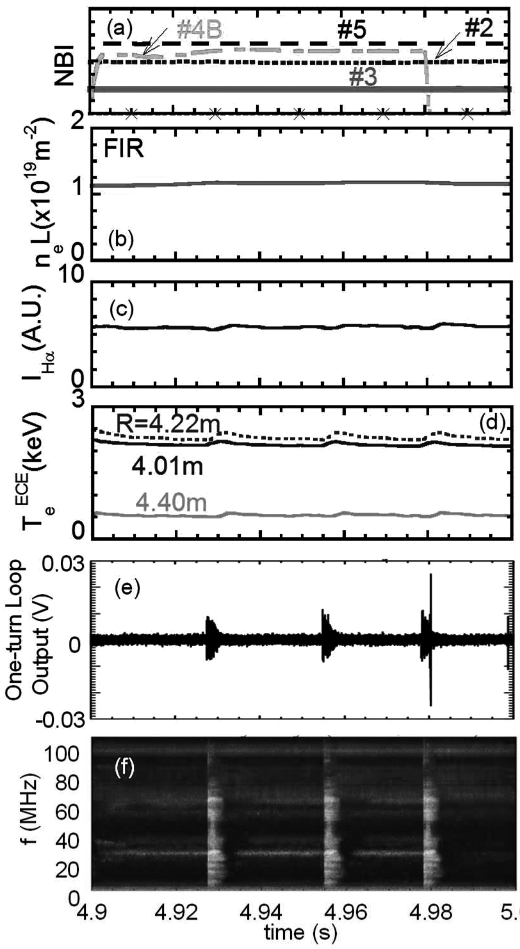

Fig. 1. Example of ion cycle emission with one-turn loop coil due to EIC bursts. Time evolution of (a) Heating, (b) line-integrated electron density, (c) H_α emission intensity, (d) electron temperature by ECE, (e) output voltage of one-turn loop coil and (d) its power spectrum.

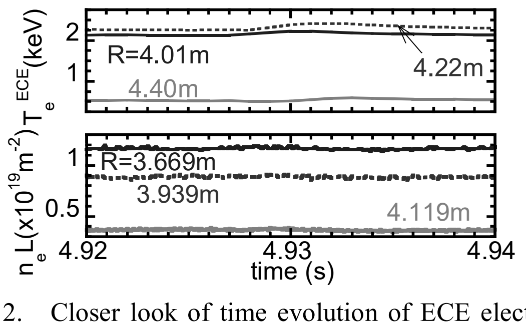

Fig. 2. Closer look of time evolution of ECE electron temperature and line-integrated electron density at the timing of one EIC burst.