§25. Radial Profile of Density Fluctuation Measurement Using Beam Emission Spectroscopy in Heliotron J

Kado, S.*, Iida, Y., Abe, S. (Univ. Tokyo),
Kobayashi, S., Nagae, Y., Ohshima, S., Mizuuchi, T., Okada, H., Lee, H.Y., Harada, T. (Kyoto Univ.),
Oishi, T., Ida, K., Okamura, S.
(* present affiliation: Kyoto Univ.)

In order to understand the anomalous transport induced by fluctuations (MHD/turbulence) in high temperature plasmas, it is important to know spatial structure of the fluctuations experimentally. Beam emission spectroscopy (BES) is a method to measure the density fluctuation at a local position using neutral beam injection (NBI). We have installed the BES system into the Heliotron J device [1]. In this paper, we report on the characteristics of the density fluctuation induced by the fast-ion-driven MHD activities in Heliotron J with respect to the response to the change in the rotational trasform by electron cyclotron current drive (ECCD).

The BES system installed in Heliotron J has 16 sightlines whose spatial resolution ($\Delta r/a$) is around ±0.07, which enables us to measure the radial profile of the density fluctuation over the entire plasma region ($0<r/a<1$) by a single shot. As the rotational transform profile is controled by changing the parallel refractive index $N_{||}$ of ECH from 0 to 0.5, toroidal current varies from 0.2 kA (Co) to -1.3 kA (Ctr). Figure 1(a) and 1(b) show the temporal evolutions of the line-averaged electron density ($\bar{n}_e$) and the power spectrum by BES at r/a=0.78 in the case of $N_{||}$=0. Two intense fast-ion-driven MHD modes were observed at f = 55 and 65 kHz. The frequencies of these modes are not sensitive to the electron density under the condition where $\bar{n}_e$ is higher than 0.6×10^{19} m^{-3}. The fluctuation intensities of BES ($\tilde{I}_{BE}/\langle I_{BE}\rangle$) for the modes, on the contrary, depends on the electron density and becomes strong at $\bar{n}_e = 0.7\times10^{19}$ m^{-3} (at the timing of t=270ms). Figure 2 shows the radial profiles of the fluctuation strength at $\bar{n}_e=0.8\times10^{19}$ m^{-3} in the case from $N_{||}$ = 0.0 to 0.5. These MHD modes are observed in the peripheral region. In the case of $N_{||}$ = 0.0, the density fluctuation strength has a peak at r/a = 0.78 and its peak position shifts in the edge region with increasing $N_{||}$. As shown in Fig. 3, the peak position and intensity of the mode is plotted as a function of $N_{||}$. The peak position of the mode moves clearly from 0.8 to 0.9 by changing $N_{||}$. This phenomenon may be due to the change in the rotational transform profile due to ECCD. Since the counter-going current increases with increasing $N_{||}$, reduction in the rotational transform is expected and a rotational transform at a certain value may shift with $N_{||}$. Then the change in the rotationa transform due to ECCD is consistent with the shift of the peak position of the mode. With the shift of the peak position by changing $N_{||}$, the totoidal current mode strength at the peak position becomes small. This implies that the control of the rotational transform profile by ECCD has a capability to reduce the fast-ion-driven MHD activity.

The MHD stability analysis will be carried out to understand the characteristics of the fast-ion-driven MHD activities. A comparison of the radial structure of the observed mode intensity and phase difference with the numerical analysis provides important informations to identify the mode. With the aim of measuring the turbulent fluctuation, we are upgrading the BES system for 2-dimensional density fluctuation measurements.

1) S. Kobayashi, et al., Rev. Sci. Inst. **83**, 10D535 (2012).

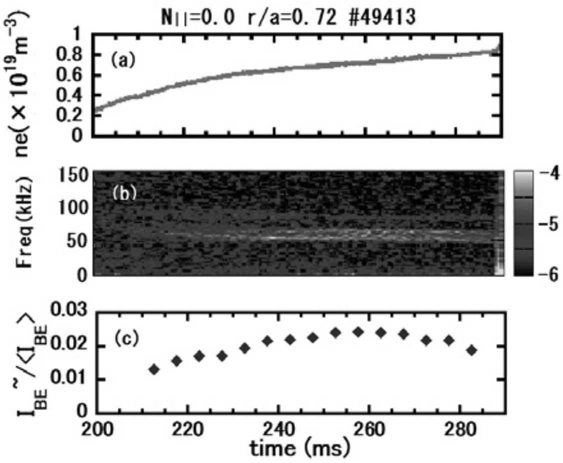

Fig. 1. Time evolution of line-averaged density, power spectrum of density fluctuation measured by BES at r/a=0.78 and fluctuation intensity in case of $N_{||}$=0. In this discharge, the toroidal current is measured to be almost zero.

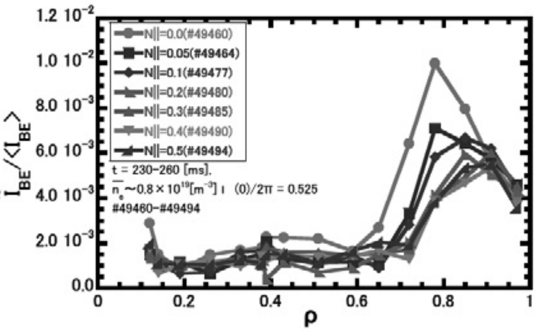

Fig. 2. Radial profile of density fluctuation intensity.

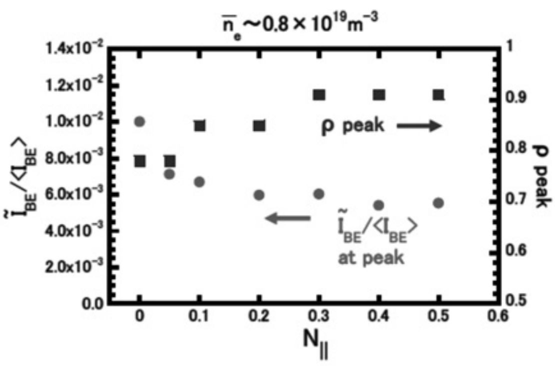

Fig. 3. Peak position of MHD modes and its strength as a function of $N_{|}$.