§25. Two-dimensional Density Fluctuation Measurement Using Beam Emission Spectroscopy in Heliotron J

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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 [1,2], which has 16 viewing chords in the radial direction. This system has a capability to measure the radial profile of the density fluctuation in the whole ($0 < r/a < 1$) plasma region in one-discharge [3]. In this FY, we have tried to investigate the propagation characteristic of the MHD fluctuation in the radial and the poloidal directions using 2 × 2 (radial × poloidal) sightlines in order to discuss the feasibility of 2-dimensional BES meausurement in Heliotron J.

The experiments were carried out in ECH + NBI (balanced injection, P_{NBI}=1.2MW) plasmas at the density of $\bar{n}_e = 0.3\times10^{19}\mathrm{m}^{-3}$. The 2 × 2 BES sightliles observed at r/a=0.20 and 0.28 and Δz = 0.01 (m). As shown in Fig. 1(a), a relatively wide-band density fluctuation was observed in the frequency range of f=5~30kHz. This fluctuation has relatively low coherence less than 0.3 to the Mirnov coil (see Fig. 1(b)). On the other hand, fluctuation with the frequency of 100~110kHz has coherence more than 0.4, which is due to fast-ion induced MHD activity.

In order to investigate the propagation of the density fluctuation both in the radial and the poloidal direction, we applied a frequency-wavenumber analysis. The frequency-wavenumber spectrum $S(f,k)$ between two adjucent viewing chords (a and b) is determied as,

$$S_{ab}(f,k) = \frac{1}{M}\sum_{j=1}^{M} I_{\Delta k}\left[k - k^j(f)\right] \times \frac{\left|S_a^j(f) + S_b^j(f)\right|}{2}, \quad (1)$$

where $S(f)$ and M are the fluctuation intensity and the number of ensembles, respectively. Figure 2(a) and (b) show the frequency-wavenumber spectra for the desity fluctuation in the frequency range of 5-30kHz in the radial and the poloidal directions, respectively. In this frequency range, the wavenumber in the radial direction k_r was in the range of -0.5 to 0.5 (cm^{-1}). On the contrary, the poloidal wavenumber k_θ was around -0.5 to -1.0 (cm^{-1}), propagating in the ion-diamagnetic-drift direction, and it was not so sensitive to the frequency. This means that the phase velocity in the poloidal direction may vary with changing the frequency.

In this analysis, the turbulent broadband fluctuation has not been identified yet because of inadequate signal-to-noise ratio. To upgrade to the 2-dimensional BES measurement, improvement in the objective optical systems is required to obtain the beam emission effectively as well as to expand the observation area. Now, we are planning to install a imaging optical fiber and a 2-dimensional detector system such as ultra fast framing (> 1MHz) camera with high sensitivity.

1) S. Kobayashi, et al., Rev. Sci. Inst. **81,** 10D726 (2010).
2) S. Kobayashi, et al., Rev. Sci. Inst. **83**, 10D535 (2012).
3) S. Kobayashi, et al., 40th EPS conf. ECA vol. 37D, (2013) P1.148.

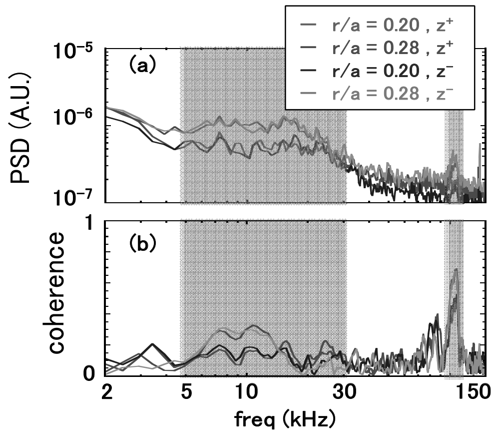

Fig. 1. (a) Power spectrum of density fluctuation measured with BES using 2 × 2 (radial × poloidal) sightlines and (b) coherence to Mirnov coil.

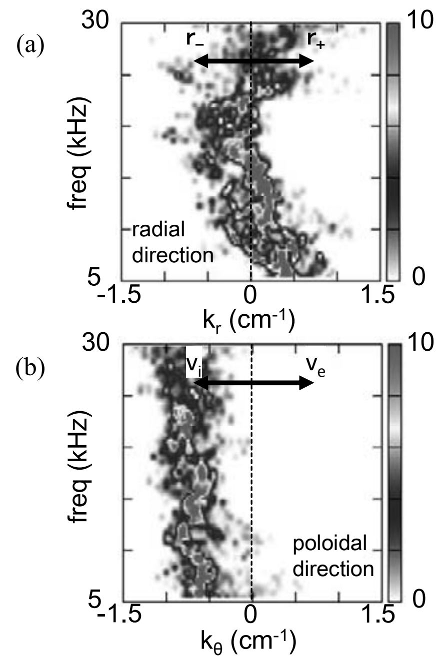

Fig. 2. Frequency-wavenumber spectra $S(f,k)$ for the density fluctuation in the frequency range of 5-30kHz between (a) radially and (b) poloidally adjacent sightlines.