§15. Study on Correlation Length of Edge Harmonic Oscillation Using Beam Emission Spectroscopy in LHD

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Edge Harmonic Oscillation (EHO) is an electromagnetic mode which appears in edge region and has equally separated harmonics of the baseband of a few kHz. In Tokamaks, EHO is observed in edge localized mode (ELM)-free Quiescent H-mode plasmas.[1] EHO has also been observed in helical devices, such as the large helical device (LHD)[2], and the compact helical device (CHS)[3]. In this study, the radial correlation length of EHO has been investigated by the use of Beam Emission Spectroscopy in LHD. The BES installed on 9O port has sightlines passing through the plasma in toroidal direction from the port by using the 100 x 15 channel fiber array. Each measurement point is around 1.0 cm in diameter, and the spatial pitch Δx is 1.0 cm. The arrangement of the fibers can be selected in the radial or poloidal direction to measure the fluctuation structures in each direction. Radial distribution of the density fluctuations can be measured using the BES with the radially-aligned sightlines. In order to improve the signal to nose ratio, several fibers are bundled up to make slits and connected to detectors. A neutral hydrogen atomic beam for heating (NBI#5) is used as the probe beam.

The plasma is produced and sustained with NBI and the magnetic axis R_{ax} of 3.6m and the troidal magnetic field strength at the magnetic axis B_{ax} of -1.00T in this experiment. The electron density is 4 x 10^{19}m^{-3}. The low-frequency harmonic fluctuations have been detected by the BES in the edge region. The temporal evolution of the power spectrum of the density fluctuation measured at the effective minor radius $r_{\mathrm{eff}} \sim 0.57$ is shown in Fig. 1 (a). Peaks have been observed at the fundamental frequency $f \sim$ 1.4kHz and its second harmonic $2f \sim$ 2.8kHz. Correlation analysis is applied during the quiet period in 3.9s < t < 4.7s. Figure 2 shows the radial profile of the squared coherence between the density fluctuation and the magnetic fluctuation. The profile of the coherence has its peak at $r_{\mathrm{eff}} \sim 0.57$m and the full width at half maximum of 6cm for the both frequency componets. For that radial position where the high coherency exists, spatio-temporal structure of the modes is analyzed. Cross-correlation function is calculated with the magnetic fluctuation as a reference signal. Figures 3 (a) and 3 (b) show the contour plot of the cross-correlation function of the fundamental component for the poloidal direction and the radial direction respectively. The vertical direction Z almost corresponds to the poloidal direction at the location of the BES sample volume. For the poloidal direction, the fundamental component at $f \sim$ 1.4kHz is found to propagate in the electron diamagnetic drift direction in the laboratory frame with a phase velocity of $v_\theta \sim$ 1.4km/s. The phase shift is also observed in the radially-aligned BES channels. Because of a possibility of a phase shift caused by rotation of the mode, it's not clear that whether the phase shift for the radial channels can be regarded as a radial propagation of the fluctuation. Further study on the radial propagation is necessary, which is left for future study.

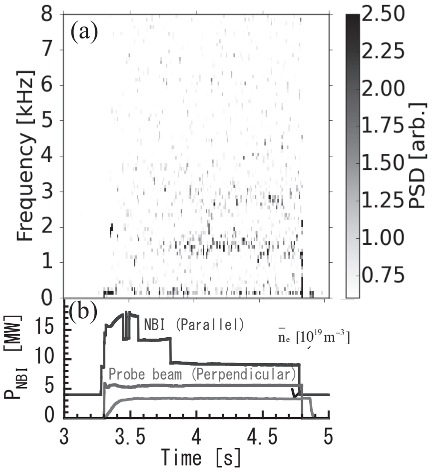

Fig. 1. Temporal evolutions of (a) power spectrum of the density at $r_{\mathrm{eff}} \sim 0.57$m and (b) the NBI power together with the line averaged density.

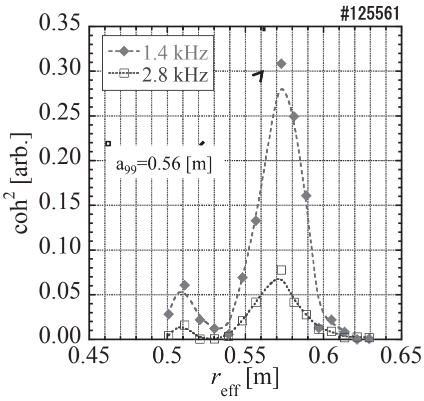

Fig. 2. Radial profiles of the coherence between the density fluctuation and the magnetic fluctuation.

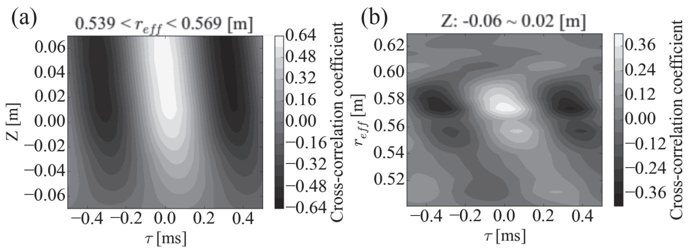

Fig. 3. Contour plot of the cross-correlation function of the density fluctuation for (a) the poloidal direction and (b) the radial direction.

1) Burrell, K.H. et al.: Phys. Plasmas **8** (2002) 2153.
2) Nagayama, Y. et al.: Rev. Sci. Instrum. **83** (2012) 10E305
3) Kado, S. et al.: J. Nucl. Mater. **363-365** (2007) 522