§10. Extension of the Observable Region of a Poloidal Beam Emission Spectroscopy System for LHD Plasmas (NIFS09KLHB301)

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Beam emission spectroscopy (BES) has been proposed as a method for the measurement of long wavelength plasma density fluctuations. The BES system measures emissions from the collisionally excited neutral beam atoms (denoted as "beam emission"). We have developed two BES systems in the large helical device (LHD). They have sightlines passing through the plasma in toroidal direction from 6T port and poloidal direction from 10.5L port, which is denoted as "toroidal sightline system" and "poloidal sightline system", respectively[1-3]. Preliminary measurement results have been obtained using both systems. However, there remains a problem that the observable region of the poloidal system having the 13 channel fiber array is about 12 cm in the radial direction, which is not sufficient to evaluate radial correlation of fluctuations over the plasma minor radius. Therefore, we tried to extend the radial width of observable region using the 50 channel fiber array in this fiscal year. Figure 1 shows the focal plane of the poloidal sightline BES system in LHD. Focal points of previous 13 sightlines and present 50 sightlines are shown together. The spatial pitch between sightlines in the plasma Δx = 9.2 mm yields the Nyquist wavenumber, $k_N = \pi / \Delta x$, of 3.4 rad cm^{-1}. Using the Larmor radius evaluated from T_e = 1 keV and B = 1.5 T, $\rho_s = (2m_i T_e / e)^{1/2} / B$, of 3.05 mm, the wavenumber range $k\rho_s < 1.04$ is measureable.

To separate the beam emission from the background emission, we designed a grating spectrometer. A low F-number was required to avoid the loss of the photon flux. We used a collimator lens with f = 200 and D = 71.4 mm, and a camera lens with f = 200 mm and D = 100 mm, and obtained the effective F-number of 200/71.4 = 2.8. Collimated light is dispersed into a spectrum by a grating with 2160 grooves per millimeter. There is a beam splitter between the camera lens and the exit slit. This beam splitter separates the intensity of the signal into 70% and 30%. The 70% component is focused on the optical fibers placed at the exit slit for the time-resolved fluctuation measurement by using Avalanche Photo-Diode detectors with a sampling rate of 1 MHz. On the other hand, the 30% component is focused on a CCD camera as a spectral image.

Density fluctuation in the edge region measured using the poloidal sightline system with extended observable region is shown in Fig. 2. The measurement was performed for the discharge aiming at achieving the high β value (#91536, B = -0.9 T, R_{ax} = 3.6 m, γ = 1.2195, B_q = 100 %), where edge MHD oscillations are frequently observed. As shown in Fig. 2(a), coherent oscillations with a frequency of 4.0 kHz appear clearly in the spectrum of density fluctuation. Figure 2(b) shows the radial profiles of coherence and phase of the fluctuation having the frequency of 4.0 kHz. A channel of R = 4.095 m shown in Fig. 2(a) was taken to be a reference. In the region of R < 4.2 m, significant coherence value was observed and phase varied continuously.

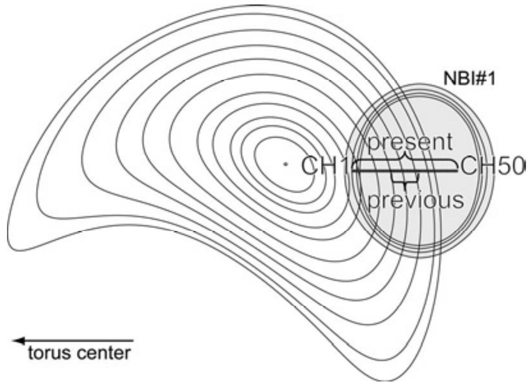

Fig. 1. Focal plane of the poloidal sightline BES system in LHD. Focal points of previous 13 sightlines and present 50 sightlines are shown together.

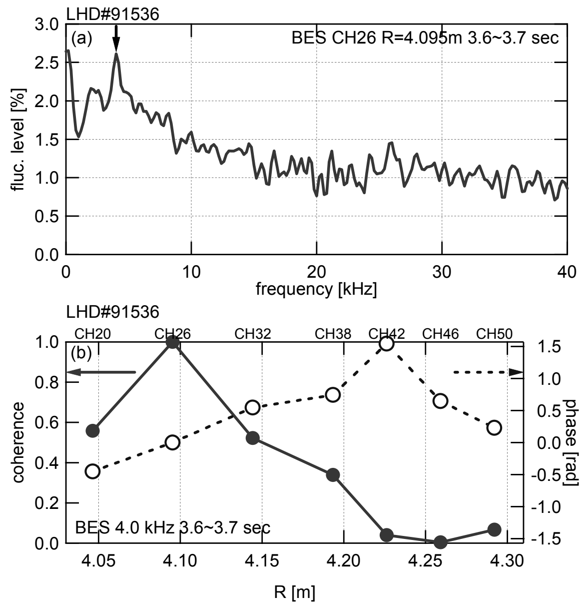

Fig. 2. Density fluctuation in the edge region measured using the poloidal sightline system. (a) Frequency spectrum at R = 4.095 m. (b) Radial profiles of coherence and phase of the fluctuation having the frequency of 4.0 kHz.

1) Kado, S. *et al.*, *submitted to* Rev. Sci. Instrum.
2) Oishi, T. *et al.*, *presented in* 18th International Toki Conference, Toki, Japan, 2008/12/09-12, P2-42.
3) Oishi, T. *et al.*, *submitted to* Rev. Sci. Instrum.