§10. Progress in Development of a Beam Emission Spectroscopy System for LHD Plasmas

Kado, S. (Univ. Tokyo),
Oishi, T. (Nagoya Univ.),
Yoshinuma, M., Ida, K.

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 a BES system in the large helical device (LHD)[1] and obtained the first data measureing MHD oscillations.[2] The prototype system has sightlines passing through the plasma in the toroidal direction (denoted as "toroidal sightline system"), and it has the spatial resolution in the radial or poloidal direction. Taking into account the results obtained using the toroidal sightline system and its specifications, we developed a new BES system aiming at improvement of the intensity of the signal and the spatial resolution in this fiscal year.[3]

As shown in Fig. 1(a), new BES system has the sightlines passing through the plasma in the poloidal direction (denoted as "poloidal sightline system"). A neutral hydrogen atomic beam for heating (NBI#1) is used as the probe beam. The angle between the sightline and the beam line is 79 deg., which yields the Doppler-shift of 2.24 nm in the H_α beam emission when the beam energy is 150 keV. Figure 1(b) is the top view. Observable region with the width of about 120 mm in nearly radial direction is focused onto the 13 channel fiber array by using an object lens having a focal length of 400 mm. By using the object lens having the diameter of 160 mm, we have succeeded in doubling the intensity of signals obtained using the toroidal sightline system having the lens of 100mm diameter. Each fiber has a numerical aperture of 0.2, a core diameter of 0.8 mm, and a clad diameter of 1.0 mm. The spatial pitch in the plasma Δx = 9.2 mm yields the Nyquist wavenumber, $k_N = \pi / \Delta x$, of 3.4 rad cm^{-1}. Using the Lamor radius evaluated from electron temperature, $\rho_s = (2m_iT_e / e)^{1/2} / B$, of 3.05 mm in the case of T_e = 1 keV and B = 1.5 T, the wavenumber range $k\rho_s <$ 1.04 is measureable. Figure 1(c) shows a cross section including the focal point of sightlines (A-A' cross section in Fig. 1(b)). We can scan the position of observable region in the radial direction with varying the angle of a mirror.

Rough estimation on the comparison of the spatial resolution between two systems is as follows. In the toroidal sightline system, sightline which is located $\rho \sim$ 0.5 (core) and $\rho \sim$ 1.0 (edge) at the focal plane passes through the intersection between the plasma and the beam from $\rho \sim$ 0.1 to 0.8 and $\rho \sim$ 0.8 to 1.0, respectively. On the other hand, the core and edge sightline in the poloidal sightline system passes through from $\rho \sim$ 0.5 to 0.6 and $\rho \sim$ 0.9 to 1.0, respectively, which indicates the improvement of the spatial resolution.

The frequency spectrum of the density fluctuation located near LCFS measured using the poloidal sightline system is shown in Fig. 2. The measurement has been performed for the discharge including edge MHD oscillations. Coherent oscillations with a frequency of 1.8 kHz, 2.2 kHz, 4.2 kHz appear clearly in the density fluctuation. Cross spectrum analysis between the density fluctuations and magnetic fluctuations has revealed that 2.2 kHz and 4.2 kHz modes are MHD oscillations.

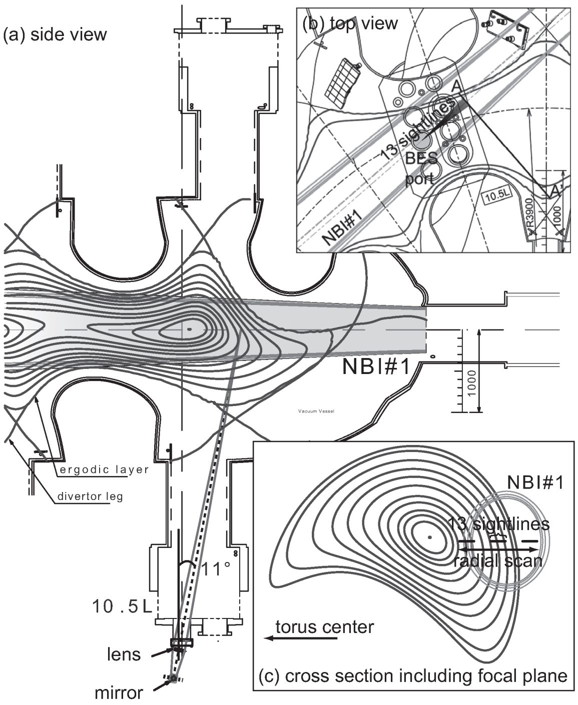

Fig. 1. Schematic drawing of the poloidal sightline BES system in LHD.

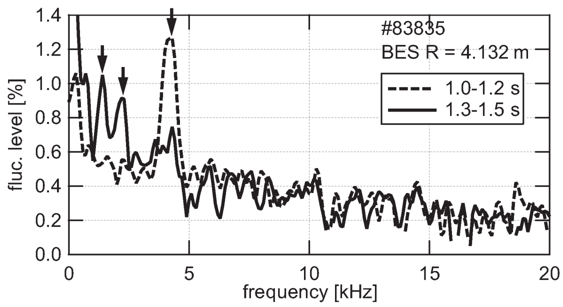

Fig. 2. Density fluctuation spectrum near LCFS measured using the poloidal sightline system.

1) Kado, S. *et al.*, Meeting Abs. Phys. Soc. Japan **61**, 1, 30aUD-12 (2006) 240. ISSN 1342-8349 [in Japanese].
2) Oishi, T. *et al.*, Meeting Abs. Phys. Soc. Japan **62**, 1, 20aQA-5 (2007) 211. ISSN 1342-8349 [in Japanese].
3) Oishi, T. *et al.*, Meeting Abs. Phys. Soc. Japan **63**, 1, 26aRE-8 (2008) 254. ISSN 1342-8349 [in Japanese].