§12. Characteristics of Radial Structure of Low-n MHD Mode in LHD

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The measurement of the spatial structure of low-n MHD modes on global plasma parameters regime is required to investigate the effect of these modes on plasma confinement performance. Magnetic measurement is often used in order to evaluate the toroidal/poloidal structure and the saturated magnetic fluctuation amplitude of MHD modes. The magnetic fluctuation amplitude of m/n=1/1 modes excited in the peripheral region of LHD plasmas depends on volume-averaged beta value $<\beta_{dia}>$ and magnetic Reynolds number S[1]. On the other hand, ECE measurement is commonly used in order to observe the radial structure of MHD modes, but it is unusable in high beta LHD plasma discharges because LHD plasmas approach high beta in the low toroidal magnetic field region and the middle/high electron density region corresponding to the cutoff region of the ECE measurement. So, SX measurement whose measurable region is unrestricted by experimental conditions is used[2]. However, the spatial resolution of the SX measurement installed in LHD is not enough to resolve the fine structure. Therefore, it was considered whether the integrated electron density measurement by the CO_2 laser interferometer with higher resolution than the SX measurement is useful for observation of the radial structure or not. This paper shows the measurable region of the radial structure by the electron density measurement. And, the dependence of the radial structure on the magnetic fluctuation amplitude which depends on $<\beta_{dia}>$ and S is also introduced as the first step to investigate that dependence on global plasma parameters.

Fig.1 shows the S/N ratio of the electron density fluctuation near the resonance of peripheral modes. The radial structure is obtained in the density region greater than the cutoff density corresponding to the dashed line. Then, the SN ratio is greater than 1.2 in $<\beta_{dia}>$=1~3%. This result suggests that the electron density measurement can observe the radial structure on high beta plasmas. Here the SN ratio is defined as $\delta I_{signal}/\delta I_{noize}$ where the δI_{signal} means fluctuation amplitude with MHD mode frequency during MHD excitation and the δI_{noise} means that amplitude before the plasma discharge.

On $n_{e,fir} < 3\times10^{19}\mathrm{m}^{-3}$ and $<\beta_{dia}> < 1.5\%$, the SN ratio is less than 1.2. However, some discharges on fixed plasma parameters enable the SN ratio to increase. This is because the δI_{noise} is decided randomly regardless of plasma parameters as shown in Fig.2. Therefore, the candidate of the noise is oscillation of optical instruments.

Fig.3 shows characteristics of the radial structure on the measurable region. The peak value and the half width of the radial structure increase with the magnetic fluctuation amplitude. This result suggests that the radial structure is extended to maintain the similar shape. The electron density fluctuation includes the line-integrated effect, but the radial structure of the fluctuation is reflected by the radial displacement of MHD modes.

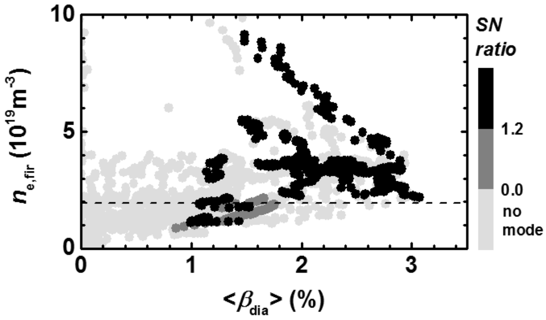

Fig. 1. The S/N ratio of the electron density fluctuation near the resonance on the region of the $<\beta_{dia}>$ and the line-averaged electron density of the plasma center $n_{e,fir}$ in discharges with the toroidal magnetic field of 1T. Dashed line means the cutoff density of the ECE measurement.

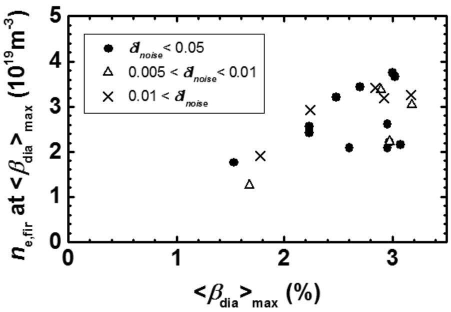

Fig. 2. Noise level of the electron density fluctuation. Here horizontal axis and vertical axis are correspond to maximum $<\beta_{dia}>$ and $n_{e,fir}$ at the time when plasmas approach maximum $<\beta_{dia}>$.

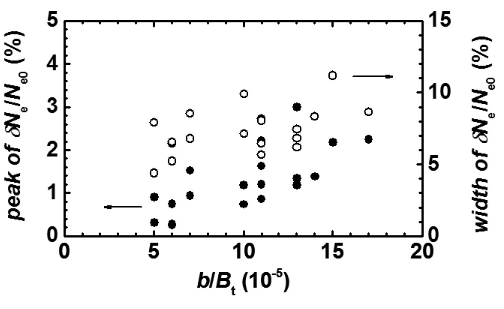

Fig. 3. Dependence of the peak/half width of the radial structure on the saturated magnetic fluctuation amplitude.

1) Sakakibara, S. et al.: Plasma Phys. Contol Fusion **50** (2008) 124014.
2) Watanabe, K.Y. et al.: Phys. Plasmas **18** (2011) 056119.