§49. Two-Dimensional Measurements of Edge Density Fluctuations in LHD and CPD

Morisaki, T., Tsuchiya, H.,
Zushi, H. (RIAM, Kyushu Univ.),
Ryoukai, T., Bhattacharyay, R. (Interdisciplinary Graduate. School of Engineering Science, Kyushu Univ.)

Density fluctuation measurements in the Large Helical Device (LHD) and the Compact PWI Experimental Device (CPD), by using a two-dimensional lithium beam probe (2D-LiBP) were carried out. Since the edge magnetic field structures in two devices are quite different, the comparison of the experimental results between them is worthwhile to understand the underlying physics of the blob phenomena.

Experiments in LHD were carried out with electron cyclotron resonance heated (ECH, 77 GHz, $P_{rf} \sim 500$ kW) plasma in relatively low averaged density range below 0.3×10^{19} m^{-3}. The toroidal magnetic field B_t was 2.7 T. On the other hand, in CPD, the plasma was initiated and sustained with ECH (8.2 GHz, $P_{rf} \sim 1$ kW) in the typical density range of $\sim 10^{18}$ m^{-3} at B_t of 0.3 T. The edge electron density and its fluctuation were two-dimensionally measured with the 2D-LiBP which utilizes the sheet-shaped thermal lithium beam widely spread on the poloidal cross section of the plasma. The fluctuating signal of Li I emission (2s - 2p, 670.8 nm) from the plasma were detected with photomultiplier tubes (PMTs) coupled with a 50-channel (5 × 10) fiber bundle at the frequency of 1 MHz for LHD and 300 kHz for CPD. Spatial resolutions of the optical system for fluctuation measurement are 50 mm for LHD and 5 mm for CPD.

From the Fast Fourier Transformation (FFT) analyses, no characteristic coherent mode was seen in the ergodic region outside the last closed flux surface (LCFS) in LHD. The spectra show the turbulent structure. On the other hand, some coherent peaks associated with drift mode instabilities were sometimes observed in the low frequency region in CPD. Nevertheless, in the high frequency region, spectra are broad and monotonically decrease with increase in frequency.

Although no coherent modes are presented in the spectra, intermittent fluctuations like bursts or "blobs" may exist and be active, which are often hidden in the spectra derived with FFT. In order to see the blob activity, the "skewness" calculated from the probability density function (PDF) were estimated for the time series data. If the skewness is positive, it means that the positive spikes are dominant in the fluctuation. On the contrary, negative skewness means negative spike fluctuations. The zero skewness is realized if the density oscillates both in positive and negative directions isotropically, i.e. the PDF presents almost Gaussian shape. Figure 1 shows the radial profiles of skewness of electron density fluctuations for LHD (a) and CPD (b). Since the skewness is always positive for both devices, it can be said that blob-like oscillation which exhausts particles from the inner region exists there. In LHD, the skewness near the LCFS is small, although it increases with the increase of the radius, as shown in Fig. 1 (a). On the other hand, in CPD, skewness is almost constant in whole region, as seen from Fig. 1 (b). For LHD, it may be interpreted that the blobs are created just outside the LCFS, then transported to the outer region, although the birth region for large tokamaks is thought to be just inside the LCFS. This is not so peculiar speculation, since LHD has the thick ergodic layer outside the LCFS, where the connection length (L_c) of the magnetic field lines is long enough to confine the plasma. In CPD, experimental result suggests that blobs are not so active in this region, because the plasma pressure is very low especially in the edge region. If the plasma parameters are increased by the improvement of the confinement performance and/or the increase of the heating power, blobs may become active, as is seen in LHD.

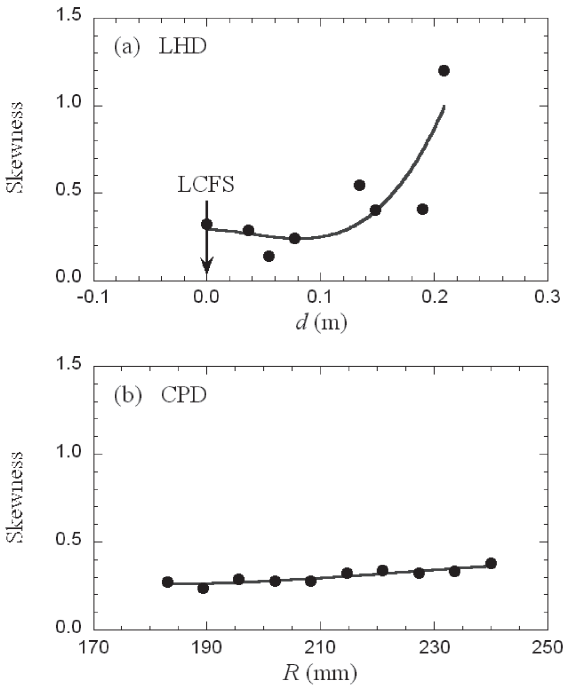

Fig. 1. Radial profiles of skewness for (a) LHD and (b) CPD.