§5. Global Correlation Technique Applied to Observe Long Range Fluctuations in LHD

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Nonlocal dynamics have been observed in LHD plasmas[1]. Macro-scale fluctuations with long distance correlation and avalanche phenomena are possible candidates to explain the nonlocal nature role in transport[2]. Identification of such long-range fluctuations and illumination of their impacts on confinement are urgent problems for both tokamaks and helical plasmas.

Recently, low frequency temperature fluctuations with long distance correlation were discovered on L-mode plasmas of LHD using global correlation measurement between fluctuations or its envelope obtained from multi-channel ECE system, a micro-wave reflectometer and magnetic probe array arranged over the full gamut of torus[3]. The 6-channel magnetic probes were aligned in the toroidal direction and the 4-channel probes were arranged in the poloidal direction as shown in Fig. 1. The target L-mode plasma is produced with neutral beam injection of 2 MW and electron cyclotron resonant heating (ECRH) of 0.8 MW is superimposed at the plasma centre. Typical parameters in this experiment are as follows: a major radius of 3.5 m, an averaged minor radius of 0.6 m, and a magnetic field strength of 2.83 T on the axis, the line-averaged density of 0.4×10^{19} m^{-3}, central electron temperature $T_e(0)$ of 4 keV. Global correlation analysis is applied during the quiet period, where the plasma has no MHD activity, without a transport barrier nor power modulation. The T_e fluctuations are observed with a multi-channel ECE radiometer. Figure 2(a) shows the cross-power spectrum of T_e fluctuations between two neighbouring points at ρ~0.4, where ρ is the normalized radius. An unambiguous peak around a few kHz with ~ 1 kHz bandwidth is visible in spectrum. Magnetic probe measures weak signal in the relevant frequency range at probe position and thus observed T_e fluctuations are not the MHD instability such as interchange modes. The ECE signals have unambiguous cross-correlation with magnetic probe signals at f = 2.5 and 3.5 kHz. The cross-phase indicates that the toroidal mode number is $n = 1$.

The spatiotemporal structure of the T_e fluctuations was determined by a two-point two-time correlation of T_e fluctuations in the range of 1.5–3.5 kHz (a band-pass filter was applied) at different radii. Figure 2(b) shows a contour plot of the correlations of T_e fluctuations with that of the reference channel at $\rho_{ref} = 0.43$. The fluctuations have a long radial correlation, which extends from the core to edge region. The radial wavelength was of the order of the plasma radius.

The existence of low-frequency temperature fluctuations has been suggested in many toroidal plasmas[4]. Fluctuations with a long distance correlation can be observed using the correlation technique reported in this study.

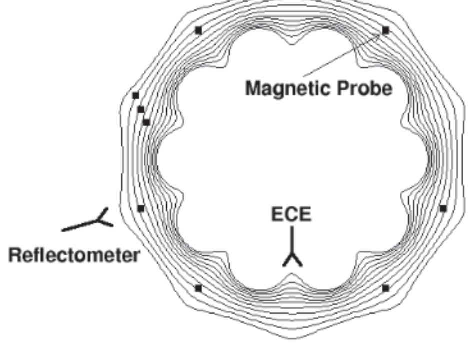
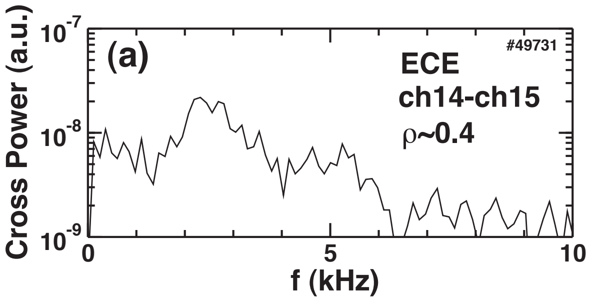


Fig. 1 Contour plot of the magnetic flux surfaces on the equatorial midplane of LHD.



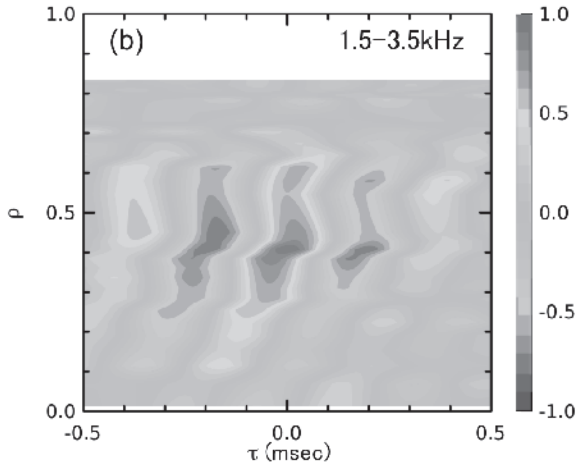


Fig. 2 (a) Typical cross-power spectrum of T_e fluctuations, (b) Contour plot of the cross-correlation function of the low-frequency component (1.5–3.5 kHz) of T_e fluctuations.

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