§28. Envelope Analysis of Density Fluctuation in Edge-core Coupled Plasmas

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To understand the turbulent transport in toroidal plasmas, some models based on local turbulence led by a local micro instability have been proposed. However, the long distance interaction of heat transport is clarified by cross-correlation between electron heat flux and electron temperature gradient in LHD. This non-locality is crucial to understanding the heat transport dynamics and it is proposed as an explanation for turbulent transport scaling with machine size. Theoretical works indicate that meso-scale structure (e.g. zonal flow) is driven by microscopic turbulence. Multiple spatial scale structures, thus, can coexist in turbulence. Correlations between the heat transport dynamics and the radial structures of turbulence are therefore essential to gain a comprehensive understanding of the turbulent transport.

It is difficult to detect a certain type of fluctuation (e.g. zonal flows) by simply using the density fluctuation diagnostics due to the low level of density fluctuation components. Recent progress in the fluctuation diagnostics (e.g. HIBP) has clarified that the microscopic density fluctuations are modulated by the meso-scale structures through a parametric modulational instability. Thus, density fluctuations have some information about structures, which can modulate them, in their envelope [1]. Two channel X-mode reflectometry was used to observe density fluctuations in discharges with a tracer encapsulated solid pellet (TESPEL) injection, where an abrupt core temperature rise takes place in response to the TESPEL ablation [2]. In order to reveal the existence of such a modulator, the envelope of higher frequency components in the reflectometry signal, which is considered to be an index of the microscopic turbulence, is extracted by using Hilbert transform. Figure 1 shows a typical signal, its envelope and the power spectrum densities of the envelope at two different radii. The reflectometry signal data from the stationary state before the TESPEL injection are used for ensemble averaging to reduce the statistical error. As shown in Fig. 1(b), the envelope is modulated. The power spectrum density of the envelope at ρ=0.45 indicates the existence of an amplitude modulator in the low frequency region ($\leq$2kHz). The low frequency component is also shown in the power spectrum density of the envelope at ρ=0.9. The cross-coherence of these low frequency components is approximately 0.3 (the significance level is 0.004) and thus the modulator in the core region may have a radial correlation length, which is much longer than that of the meso-scale structures (e.g. 3cm for zonal flows). Fluctuation of the long wavelength mode excited from background micro fluctuation is a possible candidate for the modulator. Fluctuations with long radial correlation length can cause edge-core coupling of heat transport.

[1] Itoh I. S., Itoh K., et. al., Plasma Phys. Control. Fusion **49**, L7-L10 (2007)

[2] Inagaki S. et. al., Plasma Phys. Control. Fusion **48** A251 (2006)

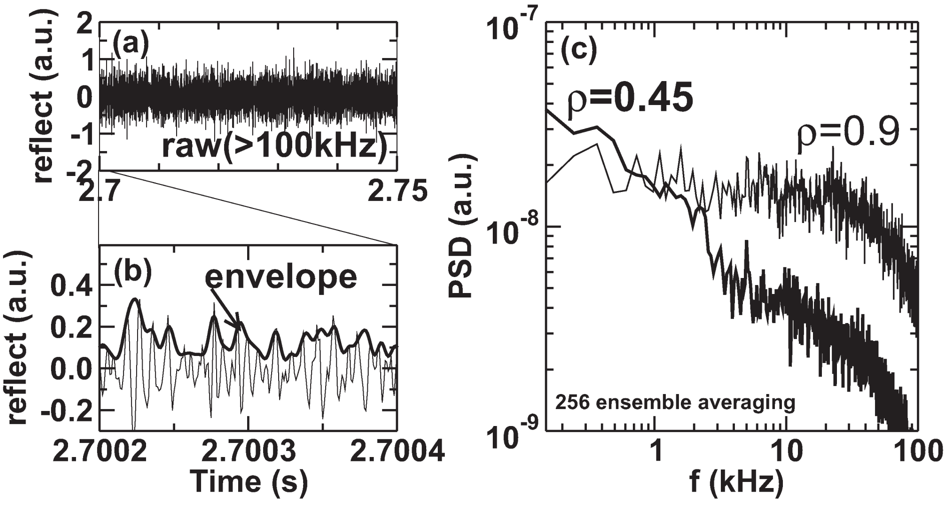

Fig. 1: (a) Time evolution of high-pass filtered signal ($\geq$100kHz) at $\rho = 0.45$ and (b) its envelope. (c) Power spectrum densities of envelope at $\rho = 0.45$ and 0.9.