§53. Characterization of the Frequency Spectra of RFP Plasma

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The decay index (f^{-a}) of the power spectrum represents a qualitative indication of an energy exchange process between fluctuations at different scales [1]. Up to now comparative studies of plasma edge fluctuations have been carried out in different magnetically confined devices. These results show the existence of three distinct frequency ranges, each with characteristic power dependence. In the intermediate frequency range it plays a possible important role in plasma transport from the previous research. This range is characterized by a power decay index close to -1 for edge plasma in tokamak and stellarator. Since the unique magnetic configuration and confinement on reversed field pinch (RFP) device more attentions should be paid [2]. It maybe exhibit different features. Unfortunately, the radial characteristic of power decay index for RFP plasma hasn't been investigated until now. The reflectrometry is one of the best diagnostics for such kind of research. In this work, microwave imaging reflectrometry (MIR) [3] has been used for the first time in the large RFP device (TPE-RX). This system can provide local plasma fluctuation information in the inner plasma while the conventional probe can't be available.

Fig. 1 shows the power spectra dependence on frequency by reflective signal and electrostatic probe signal. The decay indexes of electrostatic probe and MIR signals show similar tendency although they detect different radial positions. The power spectrum shows the power law decay like f^{-2} in the frequency range 10-70 kHz and f^{-4} in the frequency of 100-400 kHz. In the lowest frequency range it shows weak dependence on frequency and peaked spectra due to the possible presence of MHD activity, plasma column drifts and movement of detecting spots (MIR signal). The power spectra exhibit different decay indexes at intermediate frequency and high frequency ranges, which imply different energy exchanging process between fluctuations at different scales. Fig. 2 shows the statistical relation between power decay index and plasma current (I_p). Where, the solid-circle represents the intermediate frequency index and the hollow-square represents the high frequency index. In the intermediate frequency range, the power decay index keeps at f^{-2} to $f^{-2.5}$ and it seems as if it is independent of plasma current. But the decay index of high frequency shows different features: when $I_p > 240$kA, it keeps at about f^{-4}. The index starts to decrease when the plasma current is lower than 240kA. It shows large discrete for the lower plasma current, partly because the amplitude of power spectrum decrease. The power decay index slightly increases with plasma theta ($\Theta = B_p(a)/\langle B_t \rangle$) as shown in fig. 3. It indicates enhanced energy exchange and high frequency (small-scale) fluctuations during high Θ period. Fig. 4 shows the radial profile of the power decay index obtained by electron density scanning. The index in the plasma core is smaller than that of plasma edge and it slightly increases with the radius. It implies there is no strong turbulence in the core region for RFP plasma. It is similar to tokamak core plasma which is mainly dominated by the sawtooth crash. The decay index of RFP for density and electrostatic fluctuation is two times higher than that of tokamak in intermediate frequency, while at high frequency domain they have the similar decay index. As we know, the transport in RFP device is much stronger than that of tokamak. From this point of view, it might to say that the transport is mainly dominated by the intermediate frequency fluctuation.

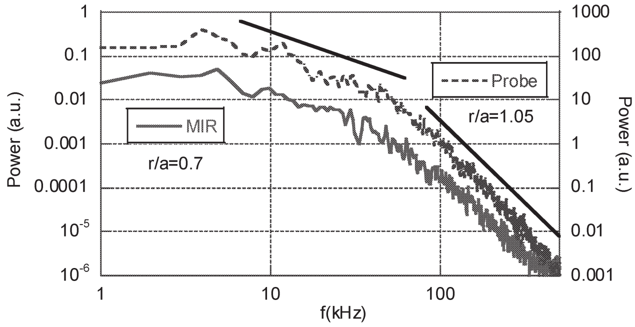

Fig. 1. Power spectra of MIR and electrostatic probe signals

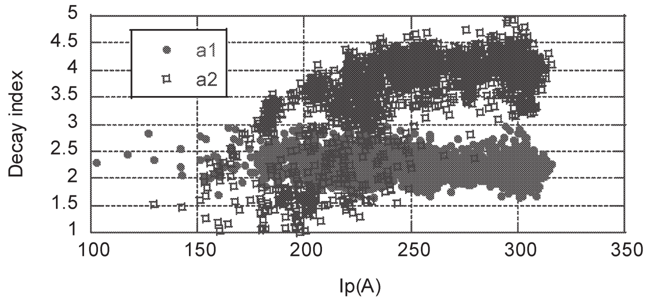

Fig. 2. Power decay indexes as a function of I_p

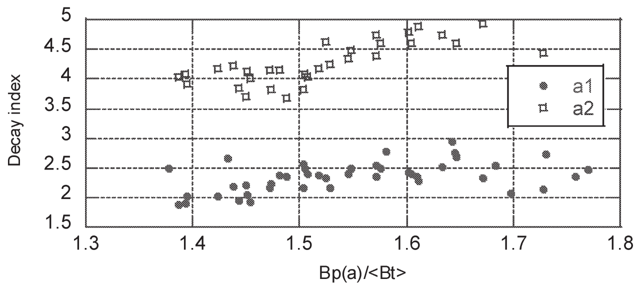

Fig. 3. Power decay indexes as function of Θ

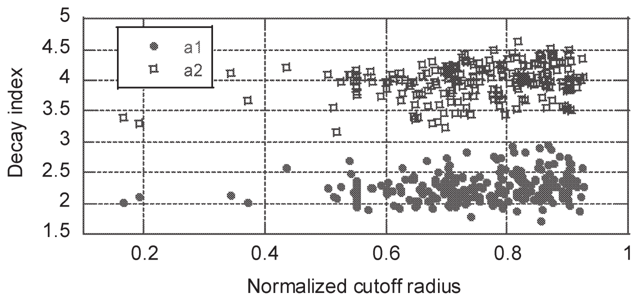

Fig. 4. Radial profile of power decay indexes

References
1) B. J. Carreras et al., Phys. Plasmas 6,(1999) 4615
2) Y. Hirano et al., Nucl. Fusion 36,(1996) 721
3) S.Yamaguchi et al., Rev. Sci. Instrum. 77, (2006) 10E930