Intermittency and nonlinear behaviors of the turbulence in the reversed field pinch plasmas

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Plasmas confined in the reversed field pinch (RFP) are well known to exhibit turbulent fluctuations and intermittency, which cause high transport by irregularly distributed short-lived events. Previous work showed that the intermittency in electrostatic turbulence correlates in time with distinct magnetic relaxation events (dynamo), and the intermittency contributes to more than 50% of the energy loss in the RFP plasmas.

The plasmas for this work were performed in the TPE-RX, a large RFP device with minor and major radii a=0.45m and R=1.72m, and plasma current capability I_p<500kA. Two types of plasma are compared. The standard plasmas are self-organized via a dynamo process involving MHD tearing instabilities. The second type of plasma is formed by modifying the inductive current drive to reduce the tearing instabilities, a technique called pulsed poloidal current drive (PPCD), which reduces the turbulence-induced transport.

This work reports on the properties of the 2D density turbulence around the reversal surface, where there are many resonant surfaces of m=0 modes (dynamo) and densely packed high n modes. The density fluctuation is measured by the microwave imaging reflectometry (MIR), which has a high sensitivity 4×4 detectors array. In the standard plasmas, the intermittency is increased as the reversal parameter $|F|$ ($F = B_t(a)/\langle B_t \rangle$) is increased. Simulation of MIR signal suggests that the intermittency in MIR signals is caused by the blob structure, which scatters the microwave and leads to a rapid decrease of the reflected power in MIR signal. The intermittent structure has a local high k mode (~40m^{-1}), which produces the long wavelength fluctuations (k<14m^{-1}) through nonlinear process. We observed high nonlinear coupling between the high k modes (k~42m^{-1}) and the low k modes (k<14m^{-1}), and the energy transfers from the higher frequency to the lower frequency. With PPCD operation, the dynamo and the high k electrostatic-like turbulence have been suppressed. The intermittency is not observed and it has high confinement as the soft-X-ray is improved.

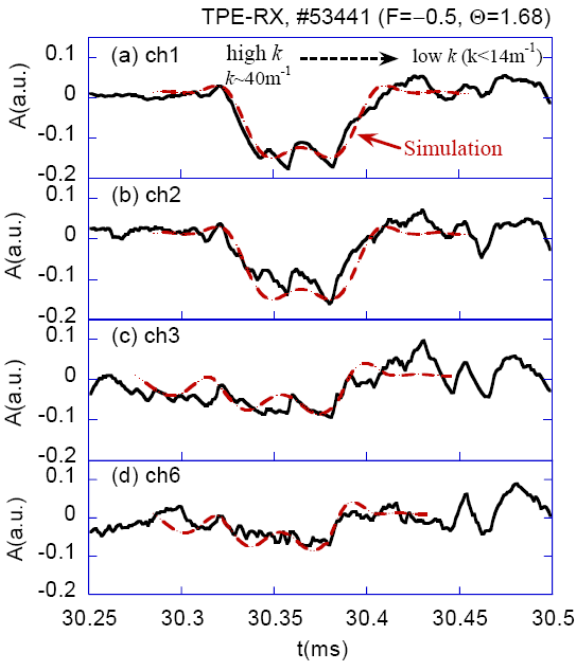

Fig. 1 Time evolution of the intermittency in the MIR signals