Microwave imaging reflectometry experiments on TPE-RX

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Many efforts have been concentrated on the research of fluctuation for the reversed field pinch (RFP) plasma, especially dynamo effect. Up to now, the edge turbulence of RFP plasma has been reported by probe and optical gas-puff imaging, while the turbulence in the inner region has not been researched due to the inaccessible condition of the electrostatic probe. The reflectometry is useful to observe the fluctuation in the inner region. This technology is based on the microwave reflected at the density-dependent cutoff layer. The spatial structure of the density fluctuations near the cutoff layer can be obtained by the reconstruction of the reflected wave front at the image plane, the phase fluctuations measured at the image plane will directly correspond to density fluctuations at the cutoff layer.

In this work, we have developed microwave imaging reflectometry (MIR) system for a large reversed-field pinch device, TPE-RX. A large aperture optical system is used instead of traditional horn antenna. The 2D antenna and detector circuits are made by the micro strip line technology, which enable high sensitive measurement. The microwave beam with frequency of 20GHz in O-mode illuminates the plasma during the experiment. Two dimensional fluctuations are observed by using MIR with spatial resolution of 3.7cm and temporal resolution of 1us. The measurements confirm several important properties of plasma edge turbulence, such as velocity shear at rho~0.9 and the intermittent behavior of quasi-single helicity (QSH) plasma. The fluctuation structures are quantified by skewness and kurtosis. The fluctuation structures of QSH plasma are featured by the negative events. But for (pulsed poloidal current drive) PPCD plasma, the high frequency fluctuations are dominated by the negative events while the low frequency fluctuations are dominated by the positive events. The k-spectrum is estimated by the maximum entropy method, which shows the existence of multi-waves. The different local peaks between the sum of the bicoherence, skewness and kurtosis suggest strong nonlinear multi-wave interactions in the RFP plasma.