§27. Fluctuation Analysis of Correlation ECE in Long Pulse Discharge

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The electron cyclotron emission (ECE) measurement is a useful for the measurement (T_e) fluctuations, and widely has been used for the study of MHD oscillation. ECE is also expected to catch the turbulence phenomena. However the frequency of turbulence phenomena is generally considered to more than several dozen kilo Hertz. The frequency range is basically the range where the ECE measurement is not available for small amplitude of fluctuation due to the sensitivity limit [1]. To reduce the thermal noise, the correlation analysis or averaging method is applied [2]. Because the sensitivity limit is proportional to the forth root of number of summation (Ns), the increasing Ns is important (i.e. the long time data in steady state is necessary). In tokamak or RFP plasma, the time of the discharge is not basically so long. In Helical devices, principally, the long pulse operation can be performed. LHD is one of the few large devices to sustain steady plasma. In this article, the trial analysis of long pulse discharge in LHD is reported.

Fig.1 shows the time development of electron temperature by ECE in long pulse discharge. The 32ch data is continuously-collected by the PXI-6133 (National Instruments) during the long discharge. The sampling frequency is 200kHz. If the time window for Fourier analysis is 33ms (2^{14} points), the Ns is 305 every 10 second. The pulse time of the analysed discharge is 2865sec. This discharge is the longest shot in this campaign. The plasma is sustained by ICRF, and the density is controlled by gas puff feedback system. The low frequency oscillation of electron temperature in Fig.1 is corresponding to the gas puff control and the swing operation of the magnetic axis.

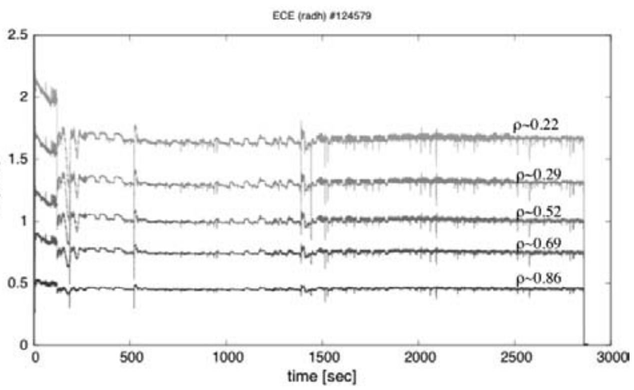

Fig. 1. The evolution of the electron temperature in the longest discharge of 2013 campaign.

Fig.2 shows the power spectra of the temperature fluctuation at ρ~0.35. We can see the 32kHz fluctuation in fig.2 a) and the 176 Hz fluctuation in Fig.2 b). The both fluctuation have coherence with the fluctuation of neighbor channel. It is also confirmed that the frequency of the 32kHz fluctuation oscillates temporally. The averaged cross spectrum in low frequency range is shown in Fig.3. The time window for averaging is 10 second. We can clearly see the higher harmonic mode (3^{rd},8^{th},10^{th}) by long time-averaging of steady state. The dependence of the cross power convergent with Ns is shown in Fig.3 b). Each power peak is saturated to steady value. This result indicates that these fluctuations are significant signal.

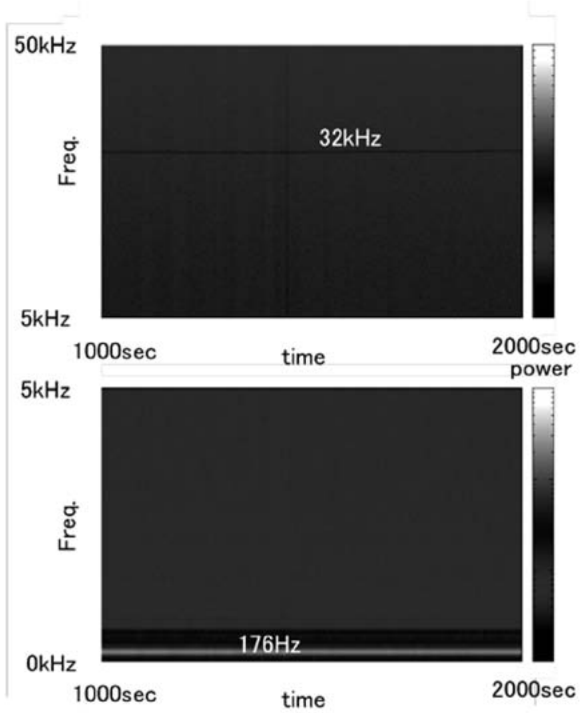

Fig. 2. Power spectra in a) high frequency range and b) high frequency range. The scale of vertical axis is linear scale.

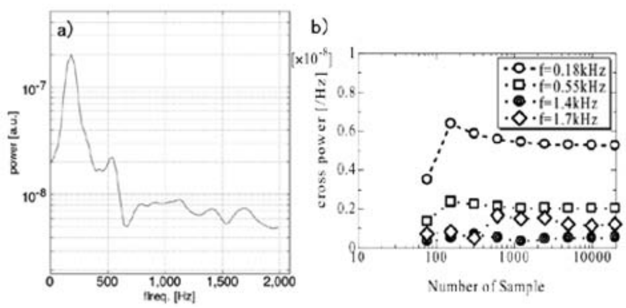

Fig. 3. a) The averaged power spectrum of low frequency range (0-2000Hz). b) The convergent of auto power in each power peak.

1) H. Tsuchiya et.al., Plasma Fusion Res. 9, 3402021 (2014).
2) C. Watts, Fusion Sci Tech. 52, 176 (2007).