Measurement of the structure of low-order MHD modes in LHD
ＬＨＤにおける低次MHDモード構造計測

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This study reports the comparison between the magnetohydrodynamic (MHD) mode structure measured by ECE (Electron Cyclotron Emission) and SX (Soft-Xray) in Large Helical Device (LHD). The MHD mode, whose frequency is 0.7~2.7kHz, is enhanced around the area of ρ = 0.8, ι = 1. The fluctuation data measured by the SX, which is included the integral effect along the line-of-sight, cannot show the mode structure clearly. At the same discharge, ECE data can identify the mode width using the displacement amplitude profile.

1. Introductions

It is well known that the edge resonant low-order modes have some effects on the radial structures such as local flattening in density or temperature profiles which may cause degradation of plasma performance. Therefore, it is quite important issue to obtain the data of magnetic fluctuations and instability mode structure, which are basic data for MHD instability study and its control [1]. In this paper, the results of the comparison between the mode structures measured by SX and ECE (Electron Cyclotron Emission) [2] are reported.

2. Experimental set up and Diagnostics

This study is performed in Large Helical Device (LHD) [3]. The MHD fluctuations are mainly measured by magnetic probe (MP) [4], Soft-Xray (SX) detectors array [5] and radiometer of electron cyclotron Emission (ECE) [2]. The frequency resolution of ECE is 1GHz. It corresponds to the spatial resolution ($\Delta\rho$~0.02). MHD or high-beta experiment are conducted in the condition of low magnetic filed B_t< 1.0T in order to clear the effect on the magnetic field. In that condition, ECE measurement cannot be used because of the cutoff in LHD. Instead, SX radiation measurement is a helpful tool for fluctuation studies. The SX detector array's spatial resolution is approximately 3mm ($\Delta\rho$~0.06) on the mid plane. Here, we have to note that the SX emission intensity is included the integral effect along the line-of-sight. Therefore, it is difficult to convert the line-integrated fluctuation data into local fluctuation value. The experiment is conducted in the condition of R_{ax} = 3.6m, B_t = 1.5T, which is suitable for ECE to be measured in 0.1 < ρ < 1. If the result of identification of mode structure used by SX is supported by the ECE measurement, this study will helps the confinement studies of the low filed discharge.

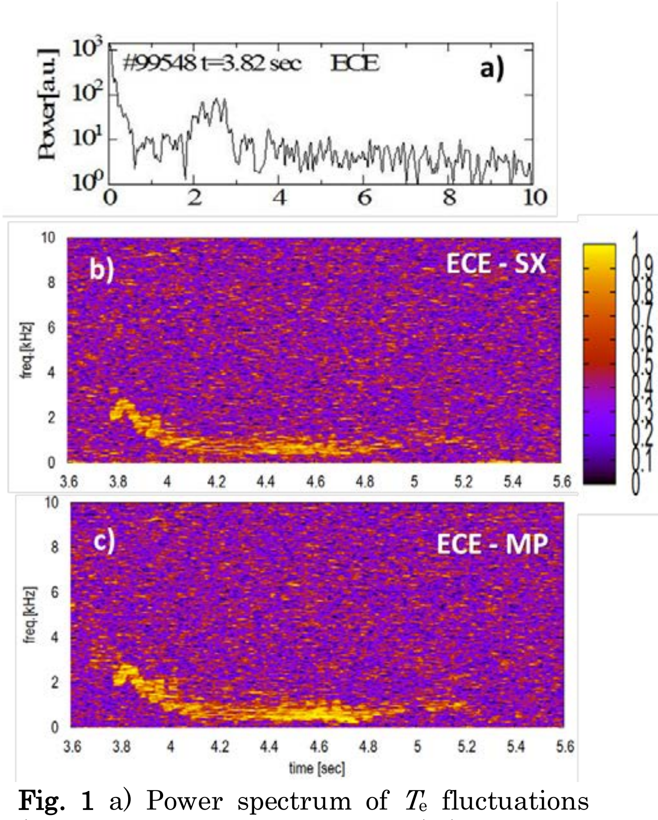

Fig. 1 a) Power spectrum of T_e fluctuations (ρ=0.84) measured by ECE b),c)Coherence evolution among ECE measurement, SX and MP. The measurement point of both ECE and SX is ρ~0.84. n_e ~ 1.5 * 10^{19} m^{-3}, T_e ~ 1.5keV.

3.Experimental Results

The MHD fluctuation of low-order mode which is seem to be m/n = 1/1 are observed by SX, MP and ECE. There are the fluctuation power peaks of ECE and SX at ρ~0.85, which corresponds to the area of ι= 1. Figure 1 a) is the power spectrum of electron temperature (T_e) fluctuation measured by ECE. We can see the existence of broad peak from 2-2.8kHz, and the peak frequency gradually decreases with the increase of toroidal currents. Fig. 1 b) and c) show the coherence among the fluctuation data of ECE, SX and MP. We can see the significant coherence of 0.7-2.8kHz. It is considered that these fluctuations are oriented from a same instability.

Fig. 2 a) shows the coherence profile calculated by T_e fluctuation. The basis channel to calculate the coherence is a channel at ρ~0.84. We can see the high coherence at ρ=0.75-0.9. In the area, T_e oscillates in the same phase, as shown Fig. 2 b).

We compare the results of the coherence profile calculated from ECE and SX fluctuation data. The coherence shown in Fig. 3 a) is average of coherence of f = 1.9 - 2.7 kHz, to take into account the broad power peak. The fluctuation exited around ρ = 0.85 seem to reach ρ = 0.6. The coherence values calculated from the SX data have a tendency to be larger than those of ECE. To clarify the mode structure, we calculated the displacement amplitude ξ. The displacement amplitude is defined as following equation.

$$\xi = \frac{-\delta f}{\delta f / \delta \rho} \qquad (1)$$

Here, f is the measured physical value. Fig.2 b) is a comparison of the displacement amplitude profile using the ECE and SX fluctuation data. When SX signal cannot show the structure clearly, we can see the mode structure using ECE data, which is local measurement tool.

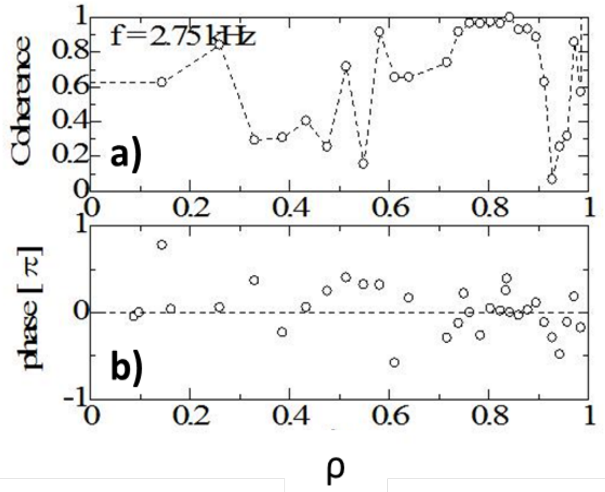

Fig. 2: a) Radial coherence profile of f = 2.75kHz. b) Spectrum Phase. The basis channel is ρ~0.84.

4.Summary

The MHD mode structure excited at ι~1 is analyzed using the SX and ECE. It is confirmed that the ECE is useful to identify the mode structure with SX measurements.

Acknowledgments

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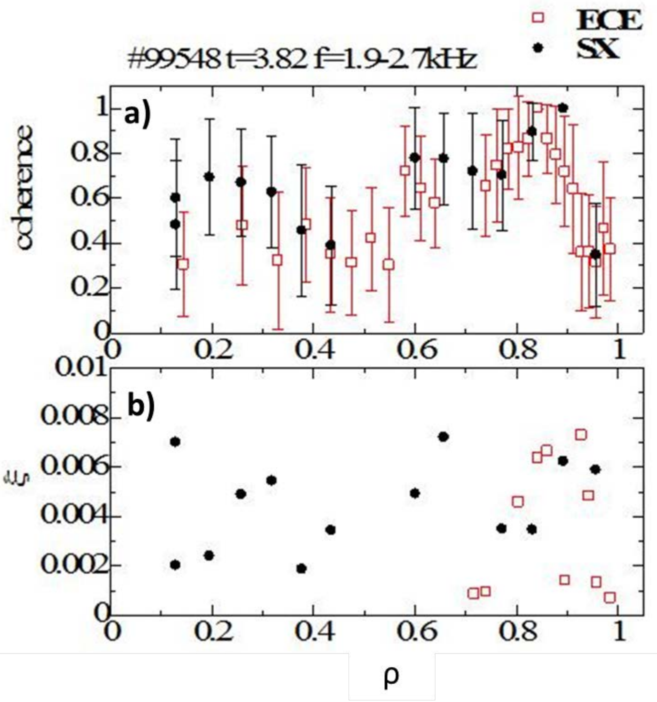

Fig. 3 Comparison of the coherence profile (a) and ξ profile (b) between ECE and SX.