§13. Measurement of Electron Temperature Turbulence with Correlation ECE Radiometer

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It is important to measure electron temperature turbulence in plasma for controlling turbulence induced transport. We have been developing and applying our correlation ECE radiometer (cECE) to LHD plasma. The measurement of the turbulence by the ECE is difficult, because, in principle, amplitude of the ECE contains noise which amplitude is proportional to the electron temperature. Recently, we have successfully detected turbulence-like signal by our cECE radiometer. In order to detect the turbulence, we decreased channel number of the measurement system and increased bandwidth of RF bandpass-filters to increase amplitude of the signals. Since wider the bandwidth of the RF bandpass-filter is employed, the measurement area becomes larger in the radial direction. This is trade-off between amplitude of the signal and detectable smallest structure size of the turbulences. In addition, analysis time window and number of ensemble averaging have to be adjusted to enlarge the amplitude of Fourier component of the cross-correlation function between two signals. If frequency of a turbulence changes in short time, the analysis time window must be shorter to detect the turbulence, however, shorter time window decreases accumulation effect of the Fourier analysis. This is the second trade-off.

Fig. 1 shows a block diagram of the cECE radiometer that we have developed. This radiometer utilizes first IF (2-26GHz) of the existent radiometer signal (RADH-L). The developed radiometer divides the IF signal into 4ch signals, and detects the amplitude of the signal with bandwidth of 200MHz at the selected frequency.

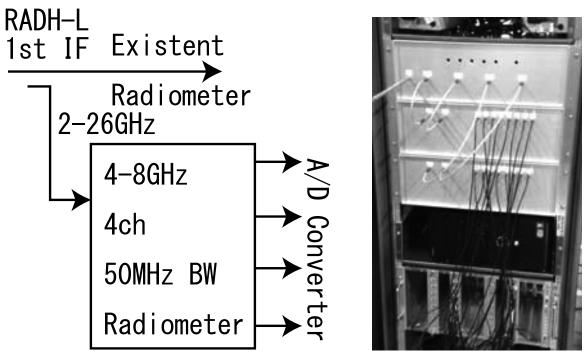

Fig. 1 a block diagram of 4ch cECE radiometer and a picture of the installed cECE radiometer system.

Fig. 2(a) and 2(b) are time evolution of cross-power spectral-density (CPSD) with two cECE channels (a), and with RADH-L channels (b). Fig. 2(c) and 2(d) are time evolution of coherence analysis with two cECE channels (c), and with RADH-L channels (d). We consider that the coherence analysis gives more accurate results compared to the CPSD analysis, since temperature noise appeared at plasma start-up (3.2 s) are disappeared in the coherent analysis. The coherence spectrum of the cECE data and that of the RADH data are almost consistent. Both systems detect temperature fluctuation that can be thought as Alfvén -wave, from 5 to 6 s around 30 kHz. Since this fluctuation may have long wavelength compared to measurement point separation of both systems, clear amplitude ridge can be detected in both analysis results. However, below 10 kHz after 5 s, the coherence analysis of the cECE data only can show large amplitude of fluctuations. We consider that these fluctuations are turbulences with shorter wavelength compared to Alfvén wave, and wide frequency component. Since measurement area of each cECE channel is shorter than that of RADH channel in the radial direction, and since separation between adjacent channels of the cECE is also shorter than that of the RADH channel in the radial direction, we consider that the cECE system only can detect turbulence with smaller structure as shown in fig. 2 (c).

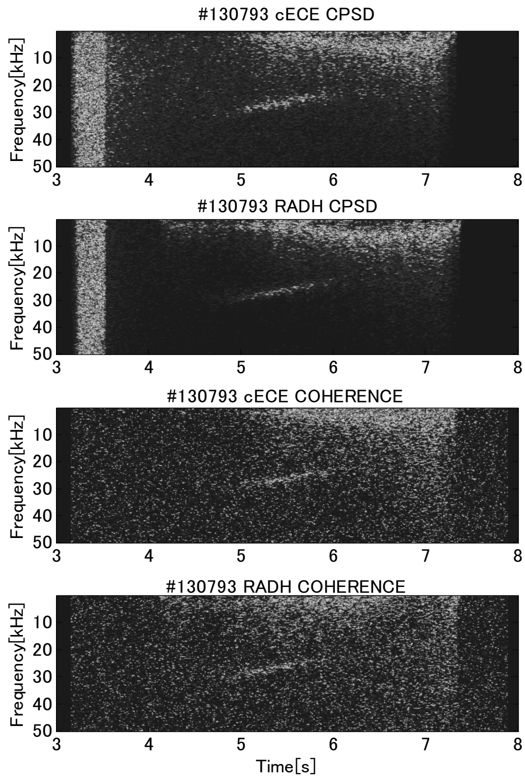

Fig. 2 Cross-power spectral density of cECE data (a) and RADH data (b). Coherence spectra of cECE data(c) and RADH data (d).