§46. Studies on Turbulence Structures in Heliotron J using Comprehensive Correlation Diagnostics

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It is necessary to understand mechanism of anomalous transport to improve plasma confinement. It is thought that anomalous transport comes from fluctuations of magnetic field, electric field, plasma density, and temperature out of various instability of plasma. Therefore, it is important to measure these parameters. Measurement of density fluctuations with electrostatic probes and a beam emission spectroscopy has been developed and used in Heliotron J. However, they can apply only to the edge plasma region. Microwave reflectometer has a capability of measuring fluctuations over the confinement region for ECH and/or NBI plasmas by choosing injection frequency. In this research, we have been developing a microwave reflectometer system to measure electron density fluctuations. The goal of the research is to clarify the behavior of electron density fluctuations in the plasma where plasma confinement is improved or energetic-particle-driven MHD instabilities are excited.

We have designed and assembled a microwave reflectometer (Reflectometer 2) in addition to an existing reflectometer (Reflectometer 1) and performed a characteristic test. Figure 1 shows the schematic of the new microwave reflectometer. The injection frequency of microwaves to plasma are fixed at 26 GHz (Ka-band), corresponding that the cut-off electron density is 0.86×10^{19} m^{-3}. Since the carrier frequency of Reflectometer 1 is scannable from 26.26 to 41.14 GHz, we are able to measure the radial correlation of turbulent fluctuation by using two reflectometers. The microwave of 8.67 GHz is generated by a voltage controlled oscillator (VCO), and it is multiplied to

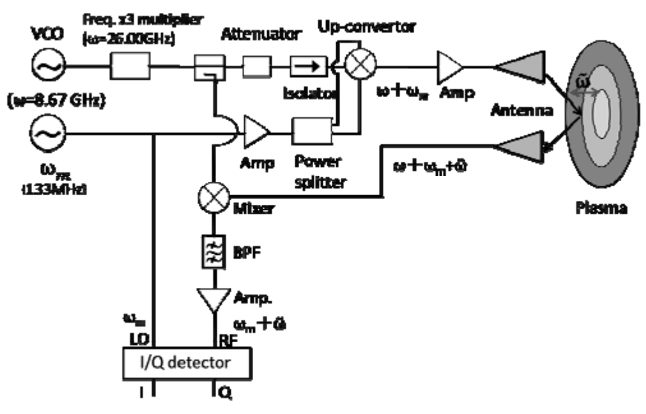

Fig. 1. Schematic of reflectometer system for density fluctuation measurement

the frequency of 26.0 GHz. The microwaves are then divided into the waves injected to plasma and the reference waves by using a directional coupler. The probe waves are up-converted to 26.133MHz by a local oscillator of 133MHz, then injected into the Heliotron J plasma and received through pyramidal horns. The received microwaves are mixed with reference waves to down-convert to the frequency of 133 MHz with fluctuations, delivering to an I/Q detector. We can estimate the complex phase difference between the received waves and the reference waves through the I and Q signals.

Using the two reflectometers, fluctuation characteristics at the transition from L-mode (Low confinement mode) to H-mode (High confinement mode) has been investigated in high-density NBI heated plasmas with high-intense gas puffing. Figure 2 shows the time evolution of the NBI plasma. The density fluctuation is suppressed during the H-mode phase. Figure 3 shows the cross-correlation of turbulence between density fluctuation at slightly different radial positions (top), and the fluctuation amplitudes measured with the reflectometer-1 (middle) and reflectometer-2 systems (bottom). The cross-correlation in radial direction increases after the transition with a time scale shorter than the energy confinement time.

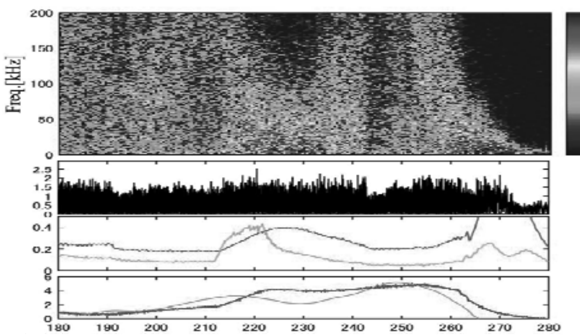

Fig. 2 the time evolution of cross correlation and fluctuation amplitude

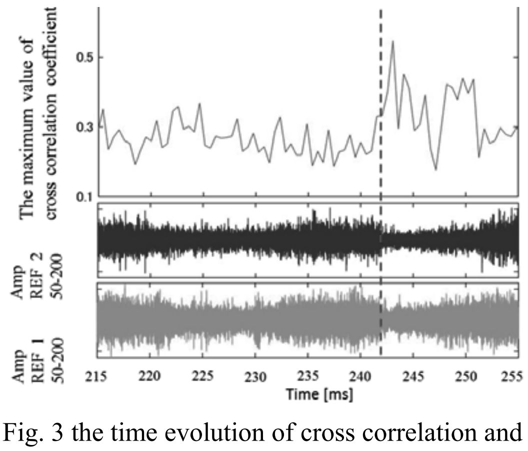

Fig. 3 the time evolution of cross correlation and fluctuation amplitude