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Study of asymmetry of edge plasma fluctuation caused by three-dimensional magnetic field configuration of Heliotron-J
ヘリオトロンJにおける周辺プラズマ揺動の3次元磁場に起因する非対称性に関する研究

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Edge plasma fluctuation in low-density electron cyclotron heating plasmas is measured with multiple Langmuir probes in Heliotron J. Correlation analysis was applied to study the fluctuation characteristics for floating potential signals, and the auto correlation function was found to be different between inside and outside the last closed flux surface.

1. Introduction

For understanding of turbulent transport and confinement properties, study of edge plasma fluctuation is an important issue. In helical devices such as heliotron and stellarator devices, inherently three-dimensional geometric effect of the magnetic configuration can lead to asymmetric turbulent transport on a magnetic surface [1], and hence multi-point measurement in whole plasma are required for the comprehensive understanding of turbulence and its induced transport. In the previous work done in Heliotron J using multiple Langmuir probes, different fluctuation characteristics were observed depending on the probe locations around last closed flux surface. Cross correlation analysis between ion saturation current and poloidal electric field fluctuations shows clearly different characteristics in different sections, which means spatio-temporal structure of fluctuation and its induced transport are also asymmetric on a flux surface [2].

In this study, we investigate the characteristics of edge fluctuation by using Langmuir probes installed at different toroidal sections in low-density electron cyclotron heated plasmas. In particular, correlation analysis using auto and cross-correlation functions was applied to clarify the fluctuation characteristics.

2. Experimental setup

Heliotron J is a medium-sized helical-axis heliotron device, and the magnetic configuration is generated by a helical coil with the pitch of L = 1/M = 4, two types of toroidal field coils and three pairs of vertical coils [3, 4].

The device is equipped with four sets of Langmuir probes at different sections, and in this study #8.5 and #11.5 probes, separated about 70 degrees in the toroidal direction, were used, as shown in Fig. 1(a) [5]. The probe head structures at #8.5 and #11.5 sections are shown in Fig. 1(b) and (c). The probe heads mainly consist of carbon and boron nitride. There are 5 carbon pins at the top sections (2mm interval), and 8 molybdenum pins at the side sections (5mm interval). The top sections are designed to locate along the magnetic surface,

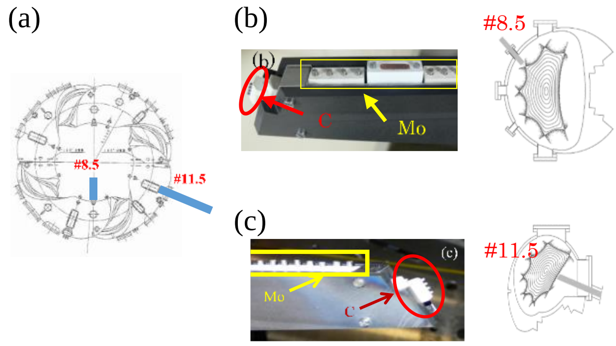

Fig.1 (a) Probe locations in the top of Heliotron J. (b)Probe head and poloidal cross section at #8.5 .(c)Probe head and poloidal cross section at 11.5

3. Experimental result and discussion

The experiment was conducted in electron cyclotron heating (ECH) plasmas with low density about $\bar{n}_e \sim 0.3\times 10^{19}\ m^{-3}$, as shown in Fig. 2(a). The Langmuir probes were scanned around the edge regions from inside to outside the last closed flux surface (LCFS).

In order to eliminate the influence of strong MHD activity on the fluctuation analysis, correlation between Langmuir and magnetic probe signals was investigated. The power spectrum of floating potential, V_f, and coherence between the floating potential and the magnetic probe signal are shown in Fig. 3. Obviously, no coherent peak is observed, which indicates the macroscopic fluctuation does not exist in the ECH discharge.

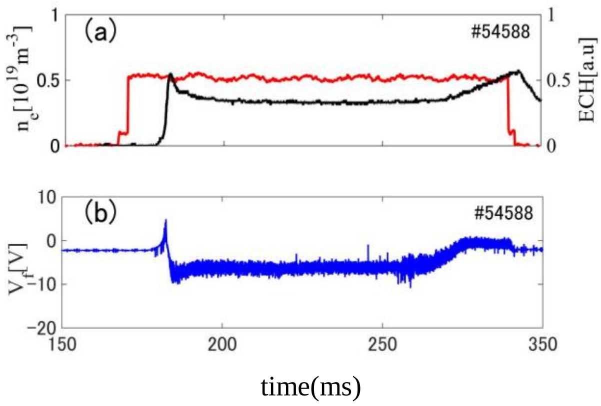

Fig.2 (a) Time development of ECH power and line averaged density measured with interferometer.
(b) Time development of floating potential Vf.

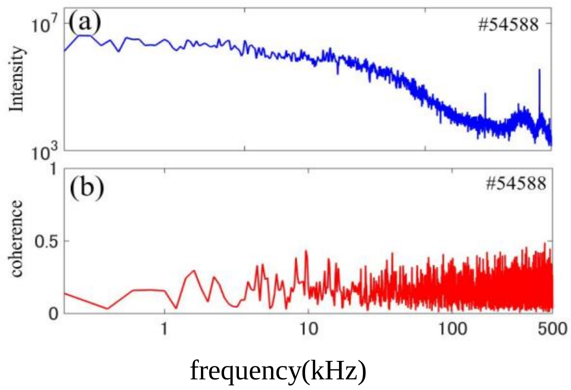

Fig. 3 (a) Power spectrum of floating potential Vf measured with #11.5 probe.
(b) Coherence between the magnetic probe signal and the floating potential Vf.

Normalized auto correlation functions of V_f at 20 mm inside and outside the LCFS are shown in Fig. 4. Before evaluating the correlation functions, we applied the band-pass filter to the floating potential signal in the frequency range of 1-100kHz. The results show different characteristics between inside and outside LCFS particularly for low frequency components and slower components of fluctuations appear more significantly inside LCFS.

In this presentation, we will report the detailed result of correlation analysis for floating potential signal, radial and poloidal electric field fluctuation and its induced Reynolds stress, and discuss differences of spatio-temporal structure of these fluctuations in different probe position.

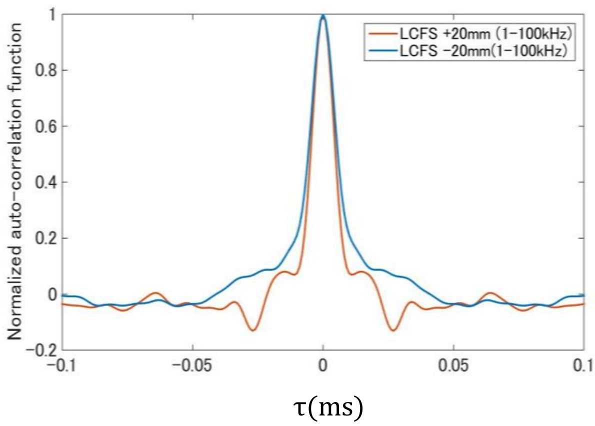

Fig. 4 Normalized auto correlation functions at # 11.5 section inside and outside of the ECH plasmas.

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