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Edge plasma fluctuation measured with multiple Langmuir probes in Heliotron J

ヘリオトロン J 装置における静電プローブによる周辺プラズマ揺動計測とその構造の解明

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Edge fluctuation characteristics and its structures are investigated using multiple probes separated in toroidal/poloidal directions in Heliotron J. Two kinds of characteristic fluctuations, an engergetic ion driven instability with higher harmonics and a low frequency mode, are observed in neutral beam heating plasma. Though these modes have quite different characteristics, both modes have nonlinear phase relationhiop with broadband fluctuations, implying the modes have influence on the broadband turbulence.

1. Introduction

Fluctuations localized at edge region have a substantial role in determining transport and performance of plasmas. Although there are various interesting phenomena relating to edge fluctuations, one of the recent issues is generation of meso-scale structure such as zonal flow or geodesic acoustic mode, which are radially localized, symmetric shear flows in poloidal/toroidal directions[1,2]. These modes are generated by turbulence itself, and can regulate and suppress the turbulence and the transport through shearing process due to the flow or energy dissipation from turbulence to the flows. These modes are studied intensively in the frameworks of both theory and experiment [1-6]. Here, from the perspectives of configuration optimization, geometry-dependent behavior of turbulence on magnetic configurations should be investigated and clarified. Heliotron J, having a widely controllable magnetic configuration, is one of good testbeds to investigate such a relationship among edge turbulence, meso-scale structures and magnetic configurations.

In this presentation, we will show and discuss the details of the characteristics and its structures of the turbulence measured with Langmuir probes in Heliotron J.

II. Experimental set up

The experiment was conducted in a helical-axis helitoron with an L/M =1/4 helical coil, Heliotron J [7,8]. The averaged major and minor plasma radii are R = 1.2 m and a = 0.17 m and the magnetic field strength of B < 1.5 T.

Figure 1 shows the probe locations in the top view of Heliotron J. The device equips with four sets of probes at different toroidal/poloidal sections. In this study, #8.5 and #11.5 probes, separated about 70 degrees in the toroidal direction each other, were used [9]. The probe head structures at #11.5 and #8.5 sections are

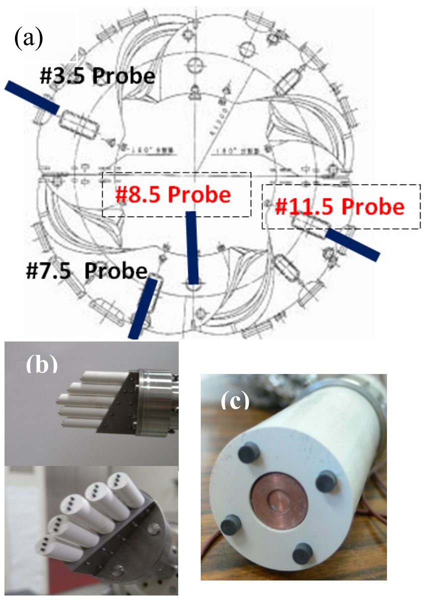

Fig.1 (a)Probe locations in the top view of Heliotron J. (b)Probe heads at #11.5 section and (c) probe head at #8.5 section.

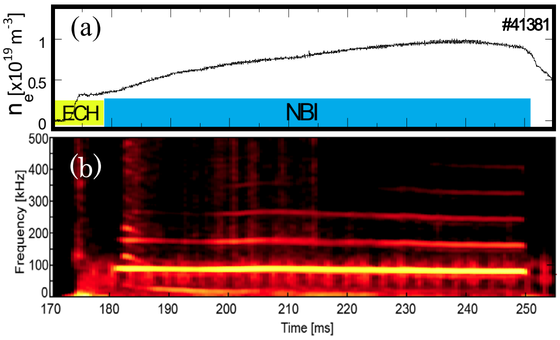

Fig.2 (a)Time development of line averaged density measured with interferometer. (b)Spectrogram of floating potential fluctuation at 4mm inside LCFS at 11.5 section.

shown in the photographs of Fig. 1(b) and (c), respectively. The probe heads mainly consists of carbon and boron nitride to be tolerant of high temperature and thermal shock.

III. Experimental Results and Discussions

Edge fluctuations at 4mm inside last closed flux surface (LCFS) were measured using the Langmuir probes in the neutral beam injection (NBI) heating plasma with low density less than 1 x $10^{19}m^{-3}$, as shown in Fig. 2(a). Two kinds of coherent modes were observed in the probe signals, as shown in the spectrogram of Fig. 2(b). These modes are categorized as an energetic-particle-driven mode at 90 kHz accompanying higher harmonics (~180, ~270…. kHz), and a lower frequency mode (LF mode) at ~20 kHz.

The energetic particle driven modes, which are relating to the Alfven eigenmode (AE), are often observed in NBI plasma of Heliotron J. Energetic particle mode (EPM) or global Alfven eigenmode are the candidates in the case of Heliotron J. The modes shown in Fig. 2 (b) are likely to be EPM since the density dependence of the frequency changes was not clear although further analysis will be needed.

The LF mode has long range correlation in toroidal direction. The correlation and phase difference between two signals measured with the probes at different location were investigated. Here one probe position was fixed at a point and the other probe position was scanned radially on shot-by-shot bases. As a result, the LF mode was found to be localized in narrow radial range inside LCFS. Additionally, since magnetic probes cannot detect the mode, the magnetic fluctuation components of the LF mode were considered not to be so strong. These characteristics of the LF mode are not inconsistent with fluctuations with meso-scale structures observed in other devices [4,5,6].

Furthermore, nonlinear characteristics of these

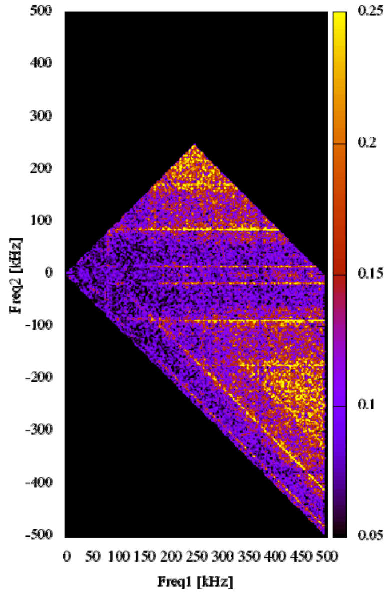

Fig.3 Result of bicoherence analysis for ion saturation current fluctuation measured with #11.5 probe at 4mm inside LCFS.

modes were investigated by applying bicoherence analysis to the probe signals. In Fig.3, nonlinear couplings were clearly observed between the LF mode at ~ 20 kHz and broad-band fluctuation in the frequency range of ~ 100-500 kHz, and also between the energetic ion driven MHD at ~90 kHz and broad-band fluctuation in the similar frequency range. This implies that these modes would affect the broadband turbulence.

IV. Conclusion

Two kinds of characteristic modes of edge plasma fluctuations were observed in NBI plasma of Heliotron J. One is a kind of Alfven eigenmodes and the other is a low frequency mode having the characteristics similar to meso-scale structures. These modes have quite different characteristics and structures, nevertheless, both modes were found to couple with broad-band fluctuation and it implies that these modes would affect the broadband turbulence.

Acknowledgments

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