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Measurement of electric field fluctuations in PANTA

PANTAにおける電場揺動計測

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In Plasma Assembly for Nonlinear Turbulence Analysis (PANTA), radial electric field fluctuations are measured by using a multi-channel probe array. The initial results in the spatial structures of electric field and its fluctuations are reported.

1. Introduction

A good confinement is essential to realize an economic fusion reactor with a magnetic and laser confinement devices of plasma. Many studies have demonstrated that electric field has strong impact on plasma turbulence transport in magnetically confined plasmas [1,2], e.g. sheared flows and zonal flows [3]. Thus, to clarify the mechanisms of plasma structural formation, it is important to observe electric field. In this study, we report the initial results of the measurements of floating potential, radial electric field and their fluctuations, using a newly made probe array, in a linear magnetized plasma of PANTA device.

2. Experimental Setup

PANTA is a device to produce a cylindrical linear plasma (diameter 0.1m, length 4m) with a helicon wave (7MHz, 3kW) by using a double-loop antenna around a quartz tube. In this experiment typical experimental parameters are 0.09T magnetic field and 3mTorr neutral gas pressure (argon). A 64-channel Langmuir probe array is used to observe the azimuthal structure of potential fluctuation. To evaluate electric field fluctuations, a 3-channel radial Langmuir probe array is used. The distance between adjacent pins is 2mm. The cut-off frequency of this probe system is 400 kHz, which was improved from that of previous value, 10kHz, by adding a new circuit to compensate the phase delay due to stray capacitance of probe. Figure 1 shows the comparison between the spectra of floating potential fluctuations measured with the new probe and a reference probe (one of the 64-channel Langmuir probe array) at r = 4cm. The spectrum measured with the new probe suggests existence of fluctuations in higher frequency range than 30kHz, while the fluctuation power in the frequency range is evaluated to be smaller with the reference probe.

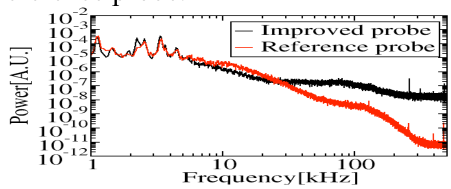

Fig.1 Auto-power spectra of floating potential fluctuations measured with the new probe and a reference probe with less sensitivity to higher frequency.

3. Experiment results

Figure 2 (a) shows the radial profile of mean floating potential measured by scanning of radial probe array in a set of discharges showing a good reproducibility with an identical condition. The profiles measured with different pins on the probe array are consistent with each other within error bars. Figure 2 (b) shows the radial profile of mean electric field. The black one is evaluated by two floating potentials, V_{f2} and V_{f3}, which are measured at a pair of adjacent pins, denoted as the second and third pins, simultaneously. The pair is selected because it has similar property. The electric field is evaluated as

$$E_r = -(V_{f2} - V_{f3})/d,$$

where, d is distance between the second and third pin (0.002m). The red one is evaluated by the gradient of floating potential of the third pin. The radial electric field is found to be negatively strong in the region of r = 3 - 4.5cm.

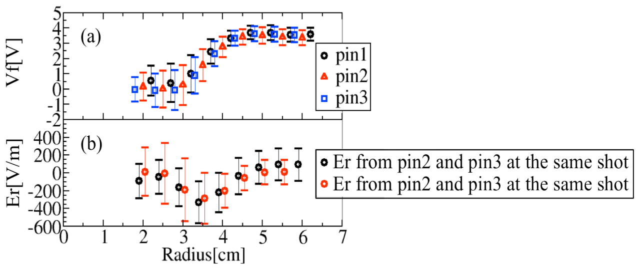

Fig.2 Radial profile of (a) mean floating potential and (b) mean electric field.

Figure 3 (a) shows radial profile of electric field spectra. The spectrum peaks of floating potential and electric field are observed at the harmonic frequencies (1.2, 2.4, 3.6kHz). Figure 3 (b) shows 2D spectra of the floating potential fluctuations measured by the 64-channel Langmuir probe array at r = 4cm. The comparison of Fig.3 (a) with Fig.3 (b) indicates that f = 1.2kHz, 2.4kHz and 3.6kHz should correspond to m = 1, 2 and 3, respectively. Here m is azimuthal mode number. The azimuthal phase velocity is evaluated as approximately 380m/s in the electron diamagnetic direction from the dispersion relation in Fig. 3(b).

By using cross phase and two-time two-point correlation between two probes whose positions differ on the same magnetic line, it is suggested that the fluctuation at f = 2.5kHz propagates both inward and outward from the radial point at r=3.8 cm. The inward and outward velocities are almost the same, that is, approximately v = 200m/s.

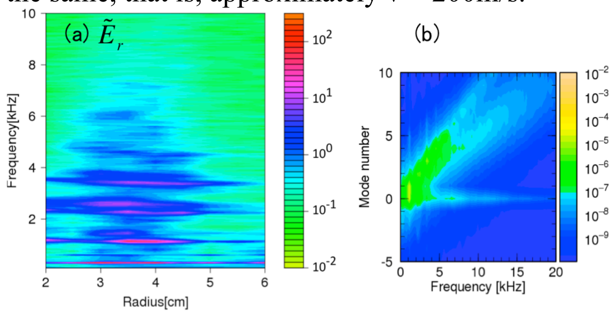

Fig.3 (a) Radial profile of auto-power spectra of electric field. (b) 2D spectra of the floating potential fluctuations.

4. Summary

Using a new probe array we have performed the measurement of the radial profiles of floating potential, electric field and the power spectrum of electric field fluctuations in a linear cylindrical plasma of PANTA device. In the discharges with magnetic field at 0.09T and gas pressure at 3mTorr, the rather coherent fluctuations characterized with harmonic frequencies and wavenumbers are found, which propagate azimuthally in the electron diamagnetic direction, and radially both inward and outward from the source position of r = 3.8 cm in the gradient regime.

In future, utilizing the new probe, it should be interesting to investigate the effects of harmonic structural oscillation on high frequency fluctuations and couplings between them. The effects of the background flows on the harmonic oscillation and higher frequency fluctuations will be possible in a controlled manner after the biasing electrode is installed on PANTA.

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