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Observation of Poloidal Direction Structure of Electron Temperature Fluctuation by Conditional Averaging Method

非平衡極限 - コンディショナル平均法による電子温度揺動の周方向構造の観測

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In the research of heat transport driven by plasma turbulence, it's important to observe temperature fluctuation and to evaluate turbulence-driven heat flux. Here we report a new technique to observe amplitude of temperature fluctuation and phase relation with other fluctuations, especially plasma potential. The new method is based on conditional sampling of the probe characteristic curve synchronizing with the most frequent temporal pattern of plasma potential signal. The method is applied to the experimental data in the PANTA (Plasma Assembly for Nonlinear Turbulence Analysis). Resulting phase difference between temperature and potential fluctuations allows us to evaluate the heat flux driven by fluctuations.

1. Introduction

Understanding of transport of magnetized plasma is one of the most crucial issues to be clarified for realization of a thermal nuclear fusion reactor. Qualitative evaluation of the heat flux driven by turbulence is strongly required. However, it is poorly understood because there are few observations of the temperature fluctuations. Recently, an evaluation method of the amplitude of electron temperature fluctuation correlated with potential fluctuation was developed by using the conditional sampling technique [1,2]. This technique is possible to estimate temperature fluctuation in-phase with potential fluctuation. When a finite phase difference exists between temperature and potential fluctuations, however, this analysis method looses its validity. The phase difference between them exists under normal conditions and is used to evaluate the fluctuation-driven heat flux and thus it is considered to be an important problem. Here we developed a new technique to statistically extract quasi-periodic temperature fluctuation in magnetized plasma.

2. New Conditional Sampling Method

The new technique is applied to the PANTA (Plasma Assembly for Nonlinear Turbulence Analysis) experiment. The PANTA generates linear cylindrical magnetized plasma (diameter 0.1m, length 4 m) by using a helicon wave (7MHz, 3kW). In our new conditional sampling technique, the prove *I-V* curves and potential fluctuation are measured simultaneously with a two-tip probe array. At the beginning, an identification of a periodical behavior of nonlinear wave, called as "template" is required as a reference signal. From Fourier analysis, the initial periodical change of the signal of interest (initial template) is estimated. A mutual correlation between raw signal and the template

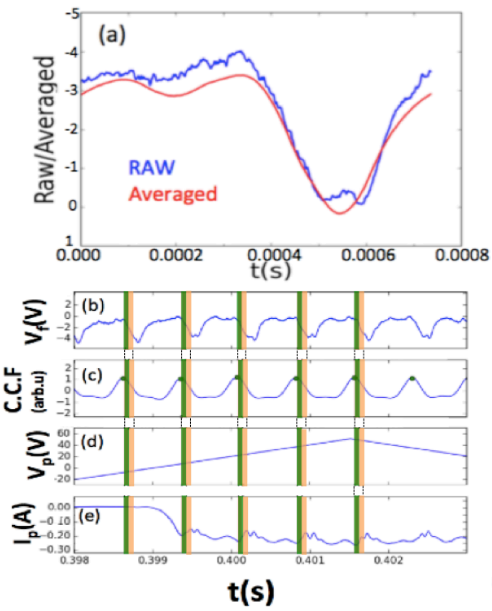

Fig.1 : (a) Typical template of the floating potential fluctuation. Temporal evolution of (b) V_f, (c) mutual correlation between raw signal and the template, (d) sweeping voltage of the Langumuir probe and (d) current flowing the probe.

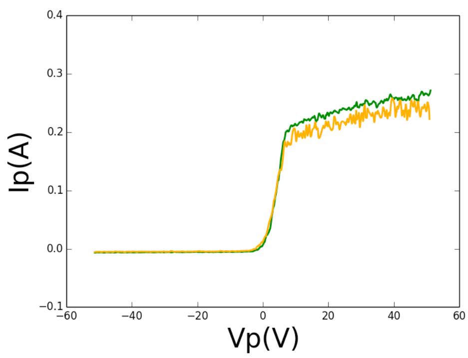

Fig.2 : Green line is V and I data sampling to green color segments in Fig.1(d) and (e). Similarly, yellow line is sampled from yellow segments in Fig.1(d) and (e).

detects a pattern similar to the template in the raw signal and produces sharp pulse-like signals. By using of the pulse-like signals as trigger, new template is obtained by using the conditional averaging technique. The above process is iterated until the template is converged [3]. Figure 1(a) shows a typical template of potential fluctuation in PANTA. The raw signal of potential fluctuation and the mutual-correlation between raw signal and template is shown in Figs. 1 (b)(c). Next, the sharp pulse-like peaks in mutual correlation are used as triggers and signals of Langmuir probe voltage and current are re-sampled as shown in Figs. 1 (d)(e). Figure 2 shows the re-sampled I-V curves at two different timings, which are indicated by green and

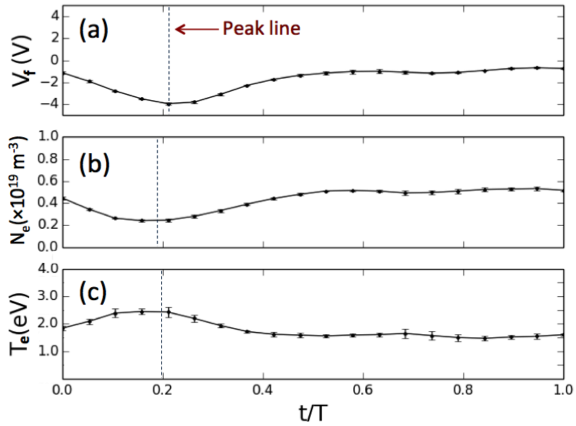

Fig.3 : Re-constracted quasi-periodical changes of (a) V_f, (b) n_e and (c) Te at r = 2cm.

yellow lines in Fig.1. Figure 3 shows reconstructed temporal evolutions of V_f, n_e, T_e at r = 2cm. Here the operational conditions in PANTA are : neutral particles pressure of 3 mtorr and magnetic field of 0.9 T. Peaks at t/T~0.2 are clealy observed, where T is the period of the template. Experimental observations indicate that the density fluctuation is in-phase with potential fluctuation. On the other hand, electron temperature fluctuation is anti-phase with floating potential fluctuation.

3. Summary

We developed the new conditional sampling techniques, and this method was applied to the PANTA experiment. We succeeded to evaluate the amplitude and phase of electron temperature fluctuation simultaneously.

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