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Measurement and Control of Plasma Turbulence in PANTA

PANTAにおけるプラズマ乱流計測及び動的制御実験の現状

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To understand fluctuation dynamics in magnetized plasma, a linear magnetic confinement device was introduced. In this device, precise spatiotemporal structure measurements of turbulence were developed and established. A turbulence control experiment by an endplate biasing was performed.

1. Introduction

The changes in turbulent structure and transport occur in much faster time scale than that expected from diffusive processes. The dynamic changes in transport are important issues for control the burning plasma states, thus, the understanding of dynamic transport response should be mandatory. According to the recent achievement, the new concept is being established that the meso-scale fluctuating structure such as zonal flows and streamers coexist with micro-scale fluctuations, so as to regulate the turbulent transport. It provides one possible path to explain the problem of dynamic transport response. Understanding of dynamics of turbulent structure formation is crucial. The purposes of this study are i) to develop and advance the physics of turbulent plasma and ii) to understand the fluctuation dynamics.

To achieve this project, a basic experimental device has been introduced. The small device provide an excellent environment to investigate fundamental processes and non-linear dynamics associated with turbulence phenomena, giving a physical understanding of plasma turbulence common for high temperature plasmas. Here, we report specifications of device and initial results of a fluctuation control experiment.

2. PANTA

PANTA (Plasma Assembly for Nonlinear Turbulence Analysis) is a linear magnetic plasma confinement device. A schematic view of PANTA is shown in Fig. 1. The cylindrical vacuum vessel has a diameter of 0.457 m and a length of 4.05 m. The device is built in a modular way and is composed of 11-modular sections. We can change a module for another one so as to easier access to plasma and to adapt a special experimental purpose. The axial magnetic field is created by 18 field coils. The coils can be moved on rails and this allows us to change the magnetic field configuration easier. The coils are usually distributed along the whole column with equal separation and create a linear magnetic field configuration. The maximum magnetic field is 0.15 T in the linear configuration. In addition, two independent coil power supplies can increase freedom of the magnetic configuration flexibility. The plasmas in PANTA are produced by helicon wave and/or electron cyclotron wave. The helicon source consists of a double-loop antenna wrapped around a glass cylinder with a diameter of 10 cm. It is powered with a 7MHz, < 10kW (typical 3kW) radio frequency. The electron cyclotron wave is excited by a 2.45GHz, 5kW magnetron. Argon (or Helium) gas is constantly injected close to the source through a mass flow controller and is pumped by two main turbo-molecular pumps close to the endplate and two sub-pumps in the middle of device. Two insulated baffle plates with the inner diameter of 15 cm are installed close to the source and endplate for neutral gas control.

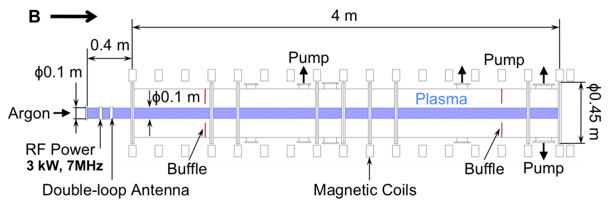

Fig.1. Schematic view of PANTA

3. Diagnostics

Langmuir probe is most suitable to measure fluctuations and equilibrium radial profiles of plasma parameters, such as electron density, electron temperature and plasma potential. Equilibrium profiles are measured with radial movable probes (with and without rf-compensation) by applying the single-, double- triple-probe methods. A 4-tips Mach probe is also used to measure equilibrium profiles of parallel- and perpendicular ion flow velocities. Spatiotemporal structure of fluctuation is measured with multi-channel probe arrays. A 64-channel azimuthal probe array and 5-channel (3-channel) radial probe arrays can measure three-dimensional structure of ion saturation current and floating potential fluctuations [1]. The fluctuation-driven radial particle flux can be also estimated from simultaneous measurement of density and poloidal electric field fluctuations with the movable 3-channel azimuthal probe array. In addition, temperature fluctuation measurement by an improved triple probe method is established [2]. A 224-channel data acquisition system with external clock (jitter < 10 ns) allows us simultaneous multi-point measurement and higher-order cross-correlation analysis of fluctuations.

4. Dynamic Control of Fluctuation

To observe the dynamic behaviors of fluctuations, the dynamic electrode biasing experiments are planed. The insulated endplate allows us biasing it and the endplate biasing experiments have been performed. The endplate biasing successfully changed potential structure as shown in Fig. 2. The impacts of the biasing on the fluctuation structure will be discussed.

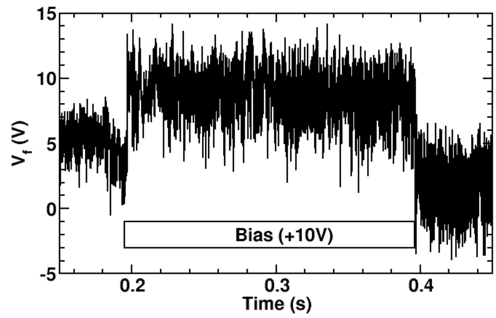

Fig. 2. Time evolution of floating potential at r = 4 cm. An endplate is biased to 10 V during discharge. The probe is separated 2 m from the endplate along magnetic field line. The endplate is electrically floated before and after biasing.

5. Summary

Plasma turbulence experiments have been conducted in PANTA. Fluctuation measurement with usual probes and advanced diagnostics such as ion flow measurement and temperature fluctuation measurements are developed and established. Turbulence control experiments by the endplate biasing have been started. Dynamic control of plasma turbulence and precise spatiotemporal structure measurement of turbulence are the most important issues in this project.

Acknowledgments

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References

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