9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Review and Prospect of Plasma Turbulence Observatory

Akihide Fujisawa
[1] Research Institute for Applied Mechanics, Kyushu University, [2] Research Center for Plasma Turbulence, National Institute for Fusion Science
e-mail: fujisawa@riam.kyushu-u.ac.jp

It is well known that magnetically confined plasmas are in turbulent states, and that the turbulence determines the plasma confinement properties. Thus, the turbulence has been intensively investigated in the research of magnetic confinement fusion. However, there various problems related to turbulence still remains unsolved. Recent research and resultant findings have provided new and modern principles to solve such problems of turbulent plasmas; cross-scale interaction and symmetry breaking of turbulence field of plasmas. In such a modern situation, new diagnostics should be needed to observe the entire plasma turbulence field.

On the other hand, the new paradigm of plasma turbulence has stimulated a new trend of plasma turbulence research in low temperature devices, which provide flexible environment for physics experiments, although it is the era for realizing burning plasmas such as International Thermo-nuclear Experimental Reactor (ITER). A flexible and special experimental environment is being realized to pursue the first-principle or physical understandings of the plasma turbulence in Kyushu University. The environment has a linear cylindrical device, Plasma Assembly for Nonlinear Turbulence Analysis (PANTA), and a toroidal device, named **PLA**sma **T**urbulence **O**bservatory (PLATO) has recently finished construction and started its experiments, being equipped with new and advanced diagnostics [1].

The major diagnostics equipped with PLATO is tomography systems that aim at entire measurement of turbulence field over plasma cross sections. A prototype of such a tomography system has been installed in PANTA, and the analysis tool for the turbulence field image obtained with the tomography has been developed [2]. The capability of turbulence field measurement has been tested, and its excellent performance is shown with newly founded physical results in 4D (space and time) measurement [3]. The examples include nonlinear interaction between background asymmetry and solitary oscillations to indicate a route to turbulence [4], and observation of spatiotemporal propagation of nonlinear coupling, and so on. Similar system is being installed on PLATO and will start its operation soon.

This paper presents the physics achievements that advanced these new recognitions of turbulent plasmas, such as radial electric field role on plasma turbulence, generation of flows and fields as a self-organization mechanism of plasma turbulence, with description on the diagnostics to bring the new insights into these issues. Finally, the article will describe a project aiming at systematic understanding of plasma turbulence in a purely physics-oriented device, PLATO, which starts its experiments.

References

[1] A. Fujisawa et al., Rev. Mod. Plasma Phys. 7:21 (2023)
[2] A. Fujisawa et al., Plasma Phys. Control. Fusion 58 025005 (2016).
[3] C. Moon et al., Sci. Report 11:2720 (2021)
[4] T-K. Kobayashi et al., Sci. Report 14:122175 (2024).

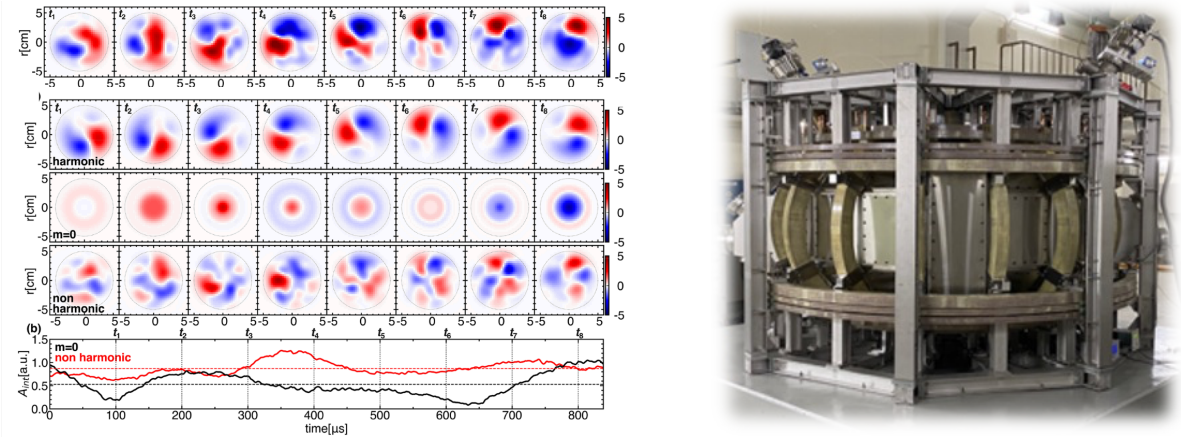

Figure 1. (left) A result obtained prototype system of tomography to perform the entire turbulence field measurement. Solitary oscillation pattern is found to be deformed through the background asymmetry [4]. (right) A picture of PLATO tokamak.