Phase-space turbulence

Organized Session: Nov. 9th, 15:00am - 18:00am (JST)

In this unit, motivated by the anomalous transport problem in magnetically confined fusion plasmas, formulation of nonlinear wave-particle interaction in turbulent field is advanced. For the fusion directed goal, roles of phase-space turbulence on anomalous transport are investigated. In high-temperature and low-collision fusion plasmas, particles are trapped in a phase of wave by which the wave potential is nonlinearly evolved and a structure forms in the phase-space (Fig. 1 left). The phase-space structure can couple with the real space plasma profile, by which a free energy is released and the phase-space structure grows (Fig. 1 right) [1]. Stochastic overlapping and cascade of the phase-space structures are also possible, resulting in emergence of the so-called phase-space turbulence. Phase-space turbulence is considered to play a role for driving anomalous transport in high temperature plasmas, involving enigmatic transport features, e.g., nondiffusivity, nonlocality, subcriticality, and others [2]. According to those theoretical predictions, survey for possible phase-space structures and examination of their contribution on plasma transport are experimentally conducted in this unit. In velocity distribution function measurement with a sufficiently high resolution, it is necessary to spread signal into the velocity dimension, which lowers the signal intensity at a single detector bin. In other words, signal intensity and measurement resolution are in a trade-off relation, which makes phase-space turbulence detection challenging.

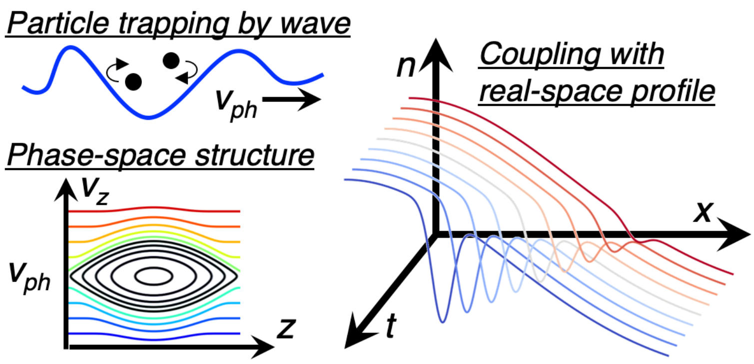

Figure 1. Overview of phase-space structure formation.

This unit attempts to overcome those difficulties by utilizing cutting-edge velocity space diagnostic systems recently being developed [3]. Perspective view of phase-space structures provided by state-of-the-art kinetic plasma simulation strongly helps optimization of diagnostic systems in surveying target turbulent phenomena. Electron scale phase-space structures are known to emerge in low-temperature and low-density basic devices, such as Q-machine, and experimental demonstration of those structures were performed previously [4]. Revisiting those classic phase-space experiments with aids of present-day diagnostic and simulation technics propel basic understanding of phase-space turbulence physics.

This session is organized as follows. Overall strategy of the unit activity is presented by Dr. Tatsuya Kobayashi (NIFS). Current status and perspective of diagnostic development for the velocity space measurement, using different diagnostic concepts, e.g., charge exchange recombination spectroscopy, conventional and corrective Thomson scatterings, and vertical electron cyclotron emission, is overviewed by Dr. Tokihiko Tokuzawa (NIFS). In the following session, a basic theoretical background of the phase-space turbulence in fusion plasmas is reviewed by Dr. Maxime Lesur (University of Lorraine). Phase-space structure formation is a general phenomenon in collisionless plasmas, and is known to occur in systems other than magnetically confined fusion plasmas. Nonlinear characteristics vary in different plasma systems, therefore comparing different cases is beneficial for a general understanding of the phase-space structure formation. As a first step, an overview of the nonlinear wave-particle interaction in the laser wake-field plasma acceleration study [5] is given by Dr. Masaki Kando (KPSI, QST).

[1] P. W. Terry, P. H. Diamond, and T. S. Hahm, Physics of Fluids B: Plasma Physics 2, 2048 (1990).
[2] Y. Kosuga, S.-I. Itoh, P. H. Diamond, K. Itoh, and M. Lesur, Nuclear Fusion 57, 072006 (2017).
[3] K. Ida, T. Kobayashi, M. Yoshinuma, K. Nagaoka, K. Ogawa, T. Tokuzawa, H. Nuga, and Y. Katoh, Communications Physics, in press (2022)
[4] K. Saeki, P. Michelsen, H. L. Pécseli, and J. J. Rasmussen, Physical Review Letters 42, 501 (1979).
[5] T. Tajima and J.M. Dawson, Physical Review Letters 43, 267 (1979).

Time table:
15:00-15:30 Tatsuya Kobayashi (National Institute for Fusion Science)
15:30-16:00 Tokihiko Tokuzawa (National Institute for Fusion Science)
16:00-16:20 Break
16:20-17:10 Maxime Lesur (University of Lorreaine)
17:10-18:00 Masaki Kando (Kansai Photon Science Institute, National Institutes for Quantum Science and Technology)