**5Bp04**

# 磁場閉じ込め乱流シミュレーションから探るプラズマ輸送の物理
# Exploring Physics of Magnetized Plasmas Transport through Turbulence Simulations

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In the magnetically confined plasma experiments, we often observe the "anomalous" transport, which has much larger transport level than the predictions by the theories based on the collisions, particle orbits, and diffusion. It is considered that the anomalous transport is caused by the turbulences driven by the micro-instabilities due to the slight fluctuations of the density and temperature of the plasmas. Since it is needed to treat the kinetic contributions of the plasmas to analyze the anomalous transport physics, the large-scale numerical simulations based on the gyrokinetic framework are strongly demanded.

In recent years, the rapid progresses of the supercomputer developments enable us to perform the turbulence simulations against realistic plasma experiments. For the plasmas obtained in the Large Helical Device (LHD) experiments, using the supercomputers, we have performed the gyrokinetic simulations and reproduced the heat transport fluxes and the spectrum of the turbulent fluctuations [1], as shown in Fig.1. Furthermore, recently, it becomes possible to perform the transport simulations for the multi particle species plasmas including not only the main ion and electron but also the hydrogen isotope ions and the impurity ions [2]. In addition to the turbulence simulations, the precise comparisons between the simulations and the experimental observations are needed to understand the plasma transport physics. The direct numerical diagnostics [3], which is one of the quite important techniques of the comparisons, are useful to capture fluctuation properties from the results of the gyrokinetic simulations and experiments. The quantitative evaluations of the numerical diagnostics, which is based on the same observation ways as the experiments, can represent a guideline for interpretation of observed signals from experiments.

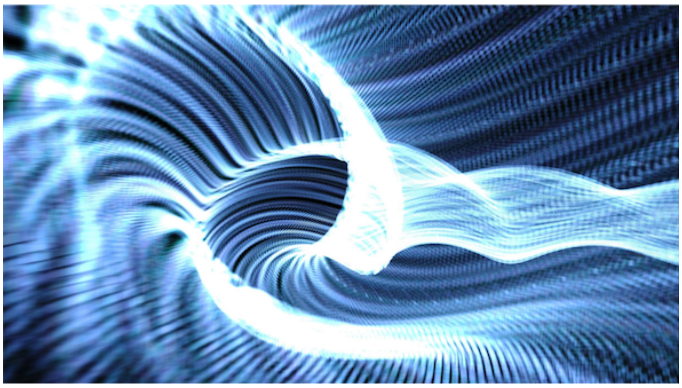

Fig. 1: A result of the gyrokinetic turbulence simulation for the electrostatic potential in high-$T_\mathrm{i}$ LHD plasma.

[1] M. Nunami, *et al.,* Phys. Plasmas **19**, 042504 (2012).
[2] M. Nakata, *et al.,* Phys. Rev. Lett. **118**, 165002 (2017).
[3] N. Kasuya, *et al.,* Nucl. Fusion **58**, 106033 (2018).