§13. Statistical Characteristics of Dynamics and Field Structure on Magnetized Plasmas

Inagaki, S., Itoh, S.-I., Yagi, M., Fujisawa, A. (Kyushu Univ.),
Itoh, K., Yamada, H.

Fundamental plasma turbulence research in a linear device on Kyushu University and advanced transport experiments in LHD (e.g. streamer formation in the linear device[1)] and non-local edge-core coupling in LHD[2)]) have established paradigm shift of turbulent transport of plasma from local and linear picture to non-local and non-linear one. According to the recent theoretical and experimental achievement, the new concept is being required that instabilities are excited by probabilistic processes and a magnetic field configuration bifurcates topologically.

This research aims at disseminating new paradigm shift from deterministic picture to probabilistic one. We clarify statistical characteristics of dynamics and field structure of magnetized plasmas through cooperation between LHD and linear device experiments.

Experiment in Linear Device: The argon plasma is produced with a 7 MHz radio frequency source operated at 3 kW of power. The magnetic field is 0.09T for this study. Spatiotemporal fluctuation measurements indicate that for a given magnetic field, the type of plasma regime is determined by the neutral pressure. At a pressure of 2 mTorr a broader drift wave spectrum is observed, whereas at a higher pressure of 5 mTorr, a large non-sinusoidal structure of main azimuthal mode number m=1 appears. Bifurcation phenomenon of fluctuations is observed in the intermediate regions (~ 4 mTorr)[3)]. Repetitive transitions occur between two bifurcated states (Phase A and B) as shown in Fig. 1. The instantaneous convective cross-field particle flux is estimated from simultaneous observations of fluctuations of density and azimuthal electric field. The azimuthal structure of the flux is measured with a 32-channel azimuthal probe array and global flux is obtained by averaging in the azimuthal direction. The probability density functions (PDF) of fluxes are evaluated. The PDF of global flux has a Gaussian distribution at high and low pressure cases. The PDF is distorted from Gaussian distribution in the phase A and B. The PDFs of local flux have a typical non-Gaussian shape with high positive kurtosis, known to arise from correlated fluctuations with Gaussian statistics and observed in many laboratory devices[4)]. The PDF of flux is related to that whether the transport is diffusive or not. The differences of statistical features between local and global fluxes have a deep impact on the understanding of the physics of the turbulence-driven transport.

Wavelet Analysis in LHD: Development of advanced methods for experimental data analysis is also in scope of our research. Heat pulse propagation experiment in LHD has been recognized to be a useful tool to study the topology of the magnetic surfaces. The wavelet transform is applied to estimate the time evolution of the phase delay in heat pulse propagation with a fine temporal resolution. The method is applied to heat pulse propagation in LHD. Various wavelet parameters are tested and the parameter region where relevant results are obtained is identified[5)]. Using of data in linear device experiments, convergence study is also performed (see Fig. 2)[6)].

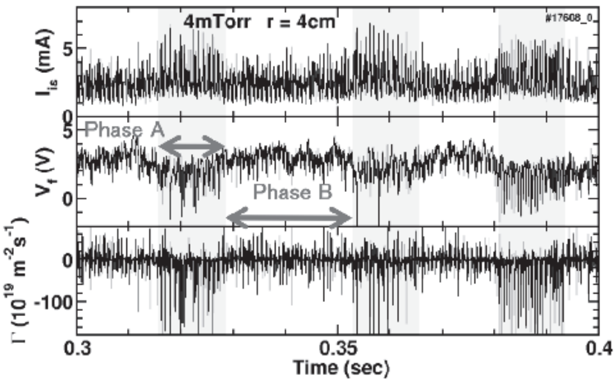

Fig. 1 Typical time evolution of ion saturation current, floating potential and fluctuation-driven particle flux at an intermediate neutral pressure (4 mTorr).

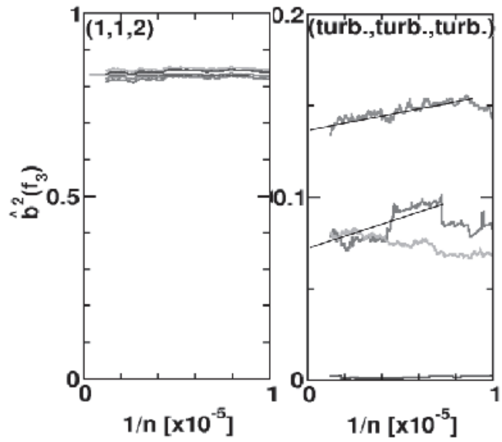

Fig. 2 Example of convergence study. The dependence of wavelet bi-coherence on number of ensembles, *n*. When the squared bi-coherences are extrapolated to the finite value when 1/*n* goes to 0, the bi-coherence is considered to be physically significant.

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4) B. A. Carreras et al., Phys Plasmas, **3** 2664 (1996)
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6) T. Kobayashi, S. Inagaki et. al., submitted to Plasma Phys. Control. Fusion