# Characterization of fluctuation and transport in KSTAR edge plasmas using the information-theoretic methodology

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Significant turbulent fluctuations are frequently measured in tokamak edge plasmas in various conditions such as the L-mode phase, the H-mode inter edge localized mode (ELM) phase, the natural ELM free phase, and the resonant magnetic perturbation (RMP) driven ELM suppression phase. We present that an information-theoretical methodology such as the Complexity Entropy analysis can extract valuable information from the measured turbulent fluctuation and particle flux signals [1].

Based on the probability distribution of amplitude orders in a given signal, the Complexity Entropy analysis [2] was proven to tell whether it is deterministically *chaotic* (e.g., generated by the logistic map) or *stochastic* (e.g., generated by the fractional Brownian motion). Here, Entropy and Complexity are information theoretic terminologies having specific meaning. Entropy means a measure of missing (unknown) information of the given probability distribution. The equiprobable distribution has the maximum Entropy because almost nothing can be learned from the equiprobable distribution. Complexity was suggested as the product of Disequilibrium and Entropy to capture the intuitive notion about a complex system [3]. Disequilibrium is another information theoretic terminology, meaning a measure of distance from the equiprobable distribution. The idea of Complexity can be understood by considering two systems (a perfect crystal and an ideal gas) regarded as simple [3]. A perfect crystal, represented by a peaked probability distribution of states, would have large Disequilibrium but very small Entropy, so their product Complexity would remain small. On the other hand, an ideal gas, represented by the equiprobable distribution of states, has large Entropy but very small Disequilibrium, so again Complexity would remain small. The location of a given signal in the Complexity and Entropy plane tells whether it is *chaotic* or *stochastic*.

The analysis result on fluctuation signals shows that the pedestal top temperature fluctuation during the RMP ELM suppression phase is stochastic, distinguished from the chaotic temperature fluctuation during the natural ELM free phase. Also, the analysis of the ion saturation current measurement around the major outer striking point on the divertor also shows that it becomes more stochastic as the RMP field increases toward the suppression level. Using the Complexity-Entropy analysis, the dynamical behavior of edge turbulent fluctuation and flux can be identified, supporting a stochastic model for the pedestal dynamics especially when a strong field penetration is applied. In addition, the origin of the stochastic fluctuation in the narrow layer on the pedestal top and the mechanism of the RMP ELM suppression were discussed based on additional spectral analyses and results of the recent numerical [4] and theoretical [5, 6] studies.

References

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