A statistical analysis approach of plasma dynamics in gyrokinetic simulations of stellarator turbulence

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A geometrical method is used for the analysis of stochastic processes in plasma turbulence. Distances between thermodynamic states can be computed according the thermodynamic length methodology which allows the use of a Riemannian metric on the phase space. The geometric methodology is suitable in order to understand stochastic processes involved in e.g. order-disorder transition, where a sudden increase in distance is expected. Gyrokinetic simulations of Ion-Temperature-Gradient (ITG) mode driven turbulence in the core-region of the stellarator W7-X, with realistic quasi-isodynamic topologies using the *GENE* [1] software are considered. In gyrokinetic plasma turbulence simulations avalanches, e.g. of heat and particles, are often found and in this work a novel method for detection is investigated. This new method combines the Singular Spectrum Analysis algorithm [2, 3], formulated for 1D and 2D data, and Hierarchical Clustering such that the gyrokinetic simulation time series is decomposed into a part of useful physical information and noise. The informative component of the time series is used for the calculation of the Hurst exponent, the Information Length and the Dynamic Time. Based on these measures the physical properties of the time series is revealed.

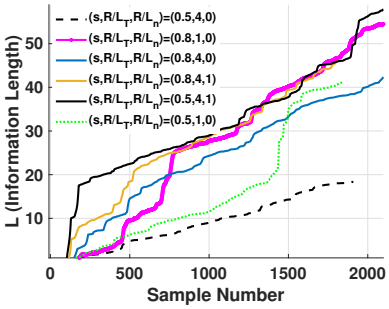

Figure 1: *Information length for the heat flux Q time series for various values of the normalized flux radius, s, temperature gradient, ΔT, and density gradient, Δn.*

References

[1] The GENE Development Team, "The Gyrokinetic Plasma Turbulence Code Gene: User Manual", http://genecode.org/

[2] N. Golyandina, V. Nekrutkin, A. Zhigljavsky, "Time Series Structure SSA and Related Techniques", CHAPMAN & HALL/CRC, (2001).

[3] J. Anderson, F. D. Halpern, P. Xanthopoulos, P. Ricci, and I. Furno, Phys. Plasmas. **21**, 122306 (2014).