On Turbulence and its Relationship With Kappa Distributions: a Langevin Approach

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Abstract

Turbulence is a complex phenomenon present in various physical systems with a large number of degrees of freedom. The effects generated by turbulence can be observed mainly in systems with high spatio-temporal correlation, achieving the universality in the characteristics that it gives to the systems that present it. In particular, space plasmas are environments in which we can measure some turbulent properties and therefore they are a vast source of study regarding this topic.

In order to study the statistical properties of turbulent systems, we consider a coupled map lattice model [1,2] and we analyze the relationship between turbulent cascades on the spatial scale and Kappa-like distributions representing the velocity probability distributions of eddies at different scales. We generate the steady-state velocity distribution of the fluid at each scale k and show that the generated distributions are well fitted by Kappa-like distributions. We observe a robust scaling relationship between the κ parameter, the scale, and the Reynolds number of the system, R_e. Our results show that there is a closed scaling relation between the level of turbulence and the κ parameter; namely $\kappa \sim R_e^{-5/3}$.

Furthermore, we also consider skew velocity distributions that usually appear in turbulent systems driven by a chaotic forcing. We consider the Ulam map noise in the lattice and fit them with Skew-Kappa distribution (Beck's distribution) [3]. We characterize the relation between κ and the skewness parameters (δ) and focus on possible physical interpretation of skewness. We expect these results to be useful to characterize turbulence in different contexts, and our numerical predictions to be tested by observations and experimental setups [4,5].

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References

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