Inverse identification of the relationship between intermittency in scalar dissipation rate and energy dissipation rate

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Intermittency, or the localized extreme fluctuations of velocity/scalar gradients in fully developed turbulent flow, results in deviations from Gaussian behavior as the Reynolds number increases, and requires anomalous corrections to Kolmogorov's theory. Intermittent behavior in turbulent scalar transport is of particular interest because it influences important practical phenomena such as combustion, particulate emissions and industrial mixing processes [1,2]. This work examines the dependence of intermittency in the scalar field on intermittency in the velocity field using a combination of traditional statistics and novel deep learning techniques. The relationship between intermittency in the energy dissipation rate and the scalar dissipation rate is investigated using homogeneous isotropic turbulence data generated using direct numerical simulations. The results indicate a notable correlation between the two quantities after accounting for a time-shift. The role of the compressive eigenvalue of the strain-rate tensor as a potential link between the intermittency in energy dissipation and scalar dissipation is also examined. Additionally, we adopt a deep learning approach (multi-layer GradCAM) to identify cohesive regions in the velocity field that have the most significant influence on scalar intermittency. This can potentially help reveal a causal relationship between the two parameters, and lead to a better understanding of the physical processes driving intermittency.

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[1]Sreenivasan, K. *Flow, Turbulence and Combustion* **72**, 115–131 (2004)
[2]K K J Ranga Dinesh et al 2010 Fluid Dyn. Res. 42 025507

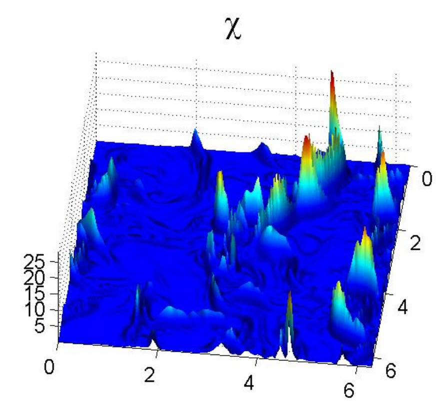

Figure 1: A 2-dimensional cross section of the scalar dissipation rate (χ) from a homogeneous isotropic turbulence DNS.