External and internal intermittency in turbulent reactive and non-reactive shear flows

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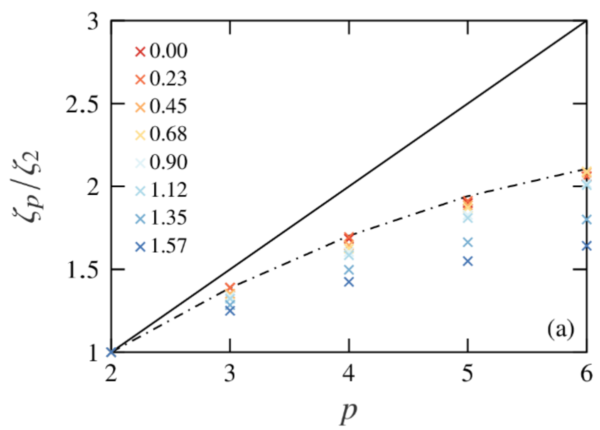
The concept of universality has played an important role in shaping our understanding of turbulent flows. However, it is well established that universality in most turbulent flows is highly compromised by the finiteness of the Reynolds number. In that case, the turbulent motion is flow dependent and boundary or initial conditions can have an effect on all scales. Specifically, for turbulent free shear flows, the turbulent motion is very different across the flow and statistics may depart significantly from classical theories.

In this presentation, the combined effect of internal and external intermittency on the statistical properties of small-scale turbulence is investigated in a temporally evolving, planar turbulent jet flow. In turbulent jet flows, the phenomenon of external intermittency originates from a very thin layer, known as turbulent/non-turbulent interface, that separates the inner turbulent core from the outer irrotational surrounding fluid. The impact of external intermittency on small-scale turbulence is studied across the jet by the self-similarity of velocity structure functions. It is shown that the scaling of structure functions exhibits a growing departure from the prediction of classical scaling solutions toward the edge. Empirical evidence is provided that this departure is primarily due to external intermittency and the associated break-down of self-similarity.

In the next step, the analysis is applied to the mixture fraction field of a turbulent non-premixed flame. In non-premixed flames, the zone of chemical reaction is located close to the turbulent/non-turbulent interface. Understanding the turbulent fluctuations in that region of the flow has therefore strong implications for turbulent mixing between fuel and oxidizer as well as the combustion process.

The analysis is based on highly resolved direct numerical simulations.



Relative scaling exponents of mixture fraction structure functions obtained by the extended self-similarity framework (ESS) for different crosswise positions. The solid line indicates analytical scaling, the dashed-dotted line corresponds to the log-normal model. The analysis reveals an increasing departure from the log-normal model with increasing distance from the center of the turbulent jet flow (red to blue symbols).