Predictability of puff decay in pipe flow

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Turbulence in pipe flow first appears in the form of localized turbulent patches known as turbulent puffs. At low Reynolds numbers, puffs tend to decay following a memoryless process[1]. However, what mechanisms are mainly responsible for puff decay, and how long in advance the decay of puffs are predictable, are still un-clear.

We investigate the features that determine the short-term predictability of puff decay. To that end we perform huge ensembles of direct numerical simulations of pipe flow at $Re = 1850$, using as initial condition N_i puffs that have a determinisitc decay event at a time t_i. Using metrics derived from information theory, particularly the Kullback-Leibler divergence, we characterise the predictability of puff decay. We show how the predictability of two puffs with a decay event at the same t_i can differ by more than one order of magnitude. We classify puffs according to their predictability, and study the common features of puffs whose decay is predictable and of puffs whose decay is not.

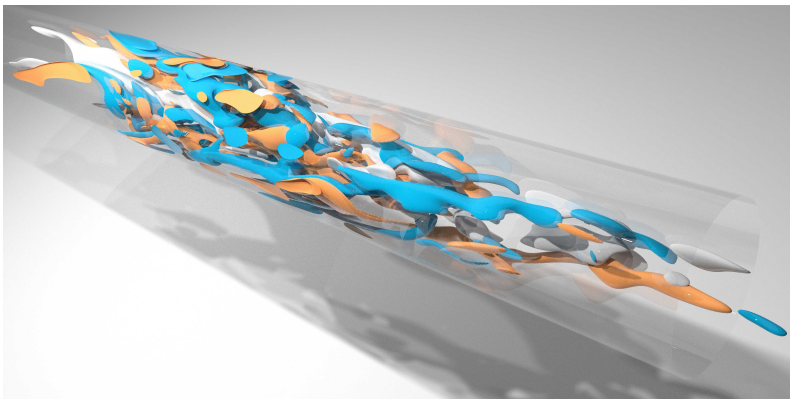

Figure 1: Turbulent puff in pipe flow at $Re = 2000$. In red/blue $\pm 4U/D$ axial vorticity. In grey $-0.4U$ low axial velocity streaks.

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[1]M. Avila *et. al*, *Annu. Rev. Fluid Mech.* **55**, 575-602 (2023).