On the structure of turbulence in shear-thinning planar jets

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Shear-thinning allows for the development of turbulence in planar jets at a value of the inlet Reynolds number lower than what observed for Newtonian jets, where the flow is steady and laminar. The fundamental mechanisms underlying the generation and sustaining of turbulence are akin to those of Newtonian turbulence: the low viscosity, observed in regions closer to the inlet, offsets the balance between inertial and viscous terms [1]. To infer on the nature of the turbulence, we make use of data-analysis tools in combination with high-fidelity data extracted from simulations. The study of the flow structures, in connection with the dynamics present in the planar jet, provides valuable information regarding the mechanisms supporting turbulence in shear-thinning fluids. The characterization of three-dimensional turbulence is the starting point of our study: we reduce the spanwise width of the jet, thus constraining the largest turbulent scale. We observe a decay of the flow to a lower dimensional regime, where fluid turbulence is confined to two spatial dimensions[2]. We complete our description of turbulence structures by exploring the properties of two-dimensional turbulence in the confined jets, where we identify three regimes depending on the turbulent scales present in the jet flow: fully three-dimensional, dimensionally-transitional (flow behaves as three-dimensional close to the inlet and it transitions to two-dimensional turbulence further downstream), and fully two-dimensional. Finally, we explore the main structures on each regime and we establish connections on the flow dynamics dictated by the shear-thinning fluid and by the confinement imposed by geometry. We observe both common and exclusive features of three- and two-dimensional turbulent dynamics, and we deduce the mechanisms induced by the flow confinement.

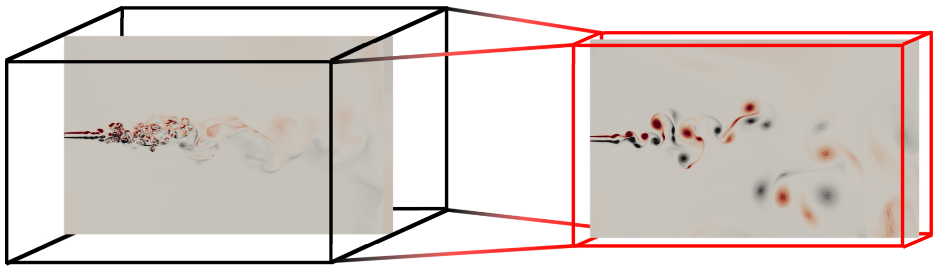

Figure 1: Sketch of the confinement process. We show the instantaneous spanwise (perpendicular to the figure) vorticity field. The confinement forces the transition from three- (left) to two- (right) dimensional turbulence.

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