Transport and mixing of passive and active scalars in turbulent viscoelastic jets and wakes analysed by DNS

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Direct numerical simulations (DNS) of spatially evolving turbulent planar jets and wakes of viscoelastic polymer solutions are performed to investigate the transport and mixing of passive and active scalars in free turbulent viscoelastic flows. The FENE-P rheological model is adopted to describe the viscoelasticity of the solutions, and the DNS is based on a highly accurate code[1,2], that employs pseudo-spectral and 6th-order compact finite difference schemes, and the shock-capturing Kurganov-Tadmor method. The polymer concentration number density is the active scalar in consideration, and allows the simulation of viscoelastic flows issuing into a Newtonian environment—figure 1a,b illustrates our DNS of turbulent planar jets. Temperature can be regarded as the passive scalar. We show that viscoelasticity can lead to a drastic suppression of small scale scalar mixing through the whole extent of the turbulent far-field, but large and intermediate scale stirring can be suppressed or enhanced, depending on the flow region in consideration and the rheological parameters of the fluid. At the high-elasticity initial portion of the far-field[2], stirring is reduced by the presence of the polymers, and so is the spreading and decay rates of passive and active scalars (Fig. 1c). In contrast, at the low-elasticity region of the far-field, the opposite effect is observed; the influence of viscoelasticity is non-monotonic. Finally, we demonstrate that the Reynolds analogy for transport of momentum and scalar is not valid for free turbulent shear flows of viscoelastic fluids.

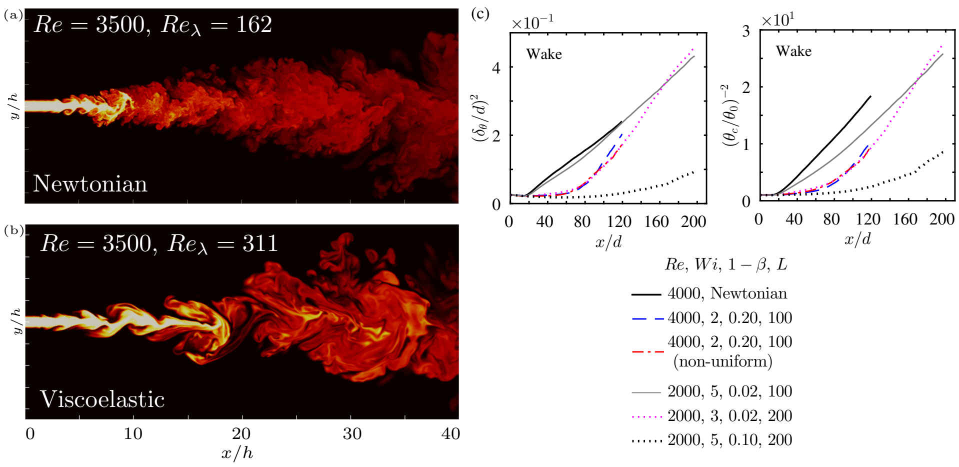

Figure 1: Two-dimensional contours of passive scalar for turbulent jets (a,b), and streamwise evolution of normalized scalar half-width and centreline value for turbulent wakes (c).

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[1]Guimarães *et al.*, *J. Fluid Mech.* **899**, A11 (2020)
[2]Guimarães *et al.*, *J. Fluid Mech.* **946**, A26 (2022)