Turbulence of dilute polymer solutions

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An interesting feature of a turbulent wall-bounded flow of a dilute polymer solution is that it shows less friction drag with respect to the flow of the pure Newtonian solvent[1]. Direct numerical simulations (DNS) of polymer solutions have been extensively used to investigate the elusive interaction between polymers and turbulence[2], using the Eulerian-Eulerian FENE-P model. A suitable Lagrangian characterisation of polymer chains, coupled with the Navier-Stokes equations for the Newtonian solvent, recently allowed to investigate of the dynamics of realistic polymer solutions[3], overcoming the limitations of the viscoelastic FENE-P model. The polymer solution dynamics is shown to depend on three dimensionless parameters, i.e. the Reynolds number Re (ratio of inertial and solvent viscous forces), the Weissenberg number Wi (ratio of polymer relaxation time and fluid time scale), and the polymer Reynolds number Re_p (ratio of solvent inertial forces and polymer viscous forces). Figure 1(a) shows a cross-section of the instantaneous axial velocity fluctuations, while figure 1(b) reports the radial profiles of mean square velocity fluctuations and the turbulent kinetic energy. Turbulent kinetic energy drastically increases above $y^+ \simeq 100$, where turbulence is found to be almost isotropic on large scales, as shown by the profiles of velocity fluctuations.

In the oral presentation, the methodological details, and the physical description of the role of polymers in the turbulence will be provided.

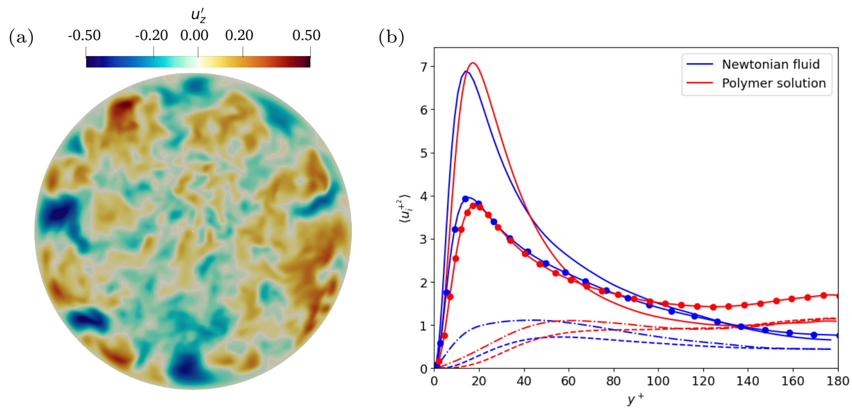

Figure 1: Panel (a): Snapshot of instantaneous axial velocity fluctuations. Panel (b): radial profiles of mean square velocity fluctuations. Solid line, $\langle u_z^{'2} \rangle$; Dashed line, $\langle u_r^{'2} \rangle$; Dot-dashed line, $\langle u_\theta^{'2} \rangle$; solid line with markers, $k = (\langle u_\theta^{'2} \rangle + \langle u_r^{'2} \rangle + \langle u_z^{'2} \rangle)/2$.

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[2]Sureshkumar et al., *Phys. Fluids* **9**, 743 (1997).
[3]Serafini et al, *Phys. Rev. Lett.* **129**, 104502 (2022).