UNIVERSITAT DE BARCELONA

Viscoelastic turbulence in oscillatory pipe flow

Thesis proposal
Starting: January 2018
Laboratory: Nonlinear Physics – Facultat de Física, Universitat de Barcelona (http://www.ecm.ub.edu/nonlinphys/english/index.html).
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Wormlike micellar (WLM) solutions, extensively used to enhance oil recovery in porous rock beds and in detergency, are also considered as model systems of fluids with complex rheological properties. WKLM solutions behave as viscoelastic Maxwell fluids at low shear rates, and are also strongly shear thinning at moderate and high shear rates. Improving our fundamental understanding of their flow behavior is important both scientifically and technologically.

This Thesis proposal is motivated by experimental results showing that oscillatory parallel shear flows of WLM solutions in a vertical pipe are readily unstable at moderate forcing amplitudes. Depending on forcing frequency the parallel flow bifurcates into a secondary flow with axisymmetric vortex rings stacked along the symmetry axis of the vertical pipe (studied in depth in our lab) or transits directly to a chaotic flow reminiscent of elastic turbulence.

The Thesis proposed here places the focus on the chaotic regime of viscoelastic turbulence, which remains unexplored. Turbulence here has its origin in the elastic properties of the fluid, rather than in the convective transport of momentum in the fluid, which remains comparatively small (low Reynolds number). Classical 2D Particle Image Velocimetry (2D-PIV) and stereoscopic 3D-PIV measurements will be carried out of the oscillatory flow induced by an oscillating piston in a large vertical cylinder. These measurements will be used to characterize the velocity flow field in the meridional plane of the cylinder, both in space and time. Local measurements of higher resolution of the velocity field are also envisaged.

The goal of the project is to obtain an accurate statistical characterization of the spatiotemporal behavior of the turbulent viscoelastic regime. Our results will be put in contrast first with other realizations of viscoelastic turbulence in flow between concentric cylinders (Couette) and between rotating disks (Von Karman), and also with classical (inertially driven) turbulence in oscillatory pipe flows of Newtonian liquids.

The research planned in this proposal is experimental, but it may also involve theory and numerical simulations through collaborations with other groups in Barcelona and abroad.

Profile: the potential candidate must be strongly motivated to carry on experimental research using sophisticated image acquisition and analysis. Knowledge of basic concepts of physical hydrodynamics and rheology of complex fluids will be highly valued.