Multiscale nature of non-Newtonian fluids

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Non-Newtonian fluids are characterized by the dependence of their viscosity and/or pressure distribution upon applied strained. The challenges in understanding and modeling the dynamics of non-Newtonian fluid flows stem from the large range of scales involved. Indeed, non-Newtonian fluids consist of diluted molecules with complex molecular dynamics. In this talk, we explore two fluids and their multiscale nature. First, we discuss flow and elastic turbulence in polymer flows. Our simulations demonstrated, for the first time, the existence of elastic-driven instabilities (i.e. driven by polymer dynamics alone) in turbulent flows. This discovery has the merit to reconcile and elucidate the many discrepancies in the knowledge of turbulent polymer flows and polymer drag reduction. Our second example is a surfactant solution that is used to resist anisotropic compression. Molecular dynamics simulations confirm the hypothesis made by Trunfio-Sfarghiu (INSA, Lyon) that superior lubrication may be achieved with lipid bilayers and vesicles made out of phospholipid molecules. We discuss the intermolecular forces at play and a surprising universal law of elasticity of lipid membranes.