Ultrasonic speckle velocimetry in sheared complex fluids

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Due to the existence of a mesoscopic scale located between the microscopic and the macroscopic scales, complex fluids show strong flow-structure coupling. Shear sometimes induces new structural organizations that coexist in the flow, leading to shear localization or shear bands. Inhomogeneous flows may thus be observed in simple shear experiments even at low Reynolds and Deborah numbers. This is the case in colloidal systems close to the jamming transition, in emulsions at the yield stress, or in surfactant systems such as wormlike micelles where an isotropic-to-nematic transition can be triggered by shearing.

Whereas classical rheology only yields global data (i.e. averaged over the whole sample), the present work is devoted to local ultrasonic velocimetry in sheared complex fluids. A high-frequency (36 MHz) speckle tracking technique is presented, that allows the spatio-temporal study of various inhomogeneous unsteady flows. An extension to two dimensional flow imaging will also be discussed.

Experimental results on various soft matter systems (wormlike micelles and lamellar phases) show the importance of spatial degrees of freedom in simple shear experiments. In most experiments, wall slip is present and may be of crucial importance in order to understand the rheological data. Moreover, both the interface between differently sheared regions and slip velocities display complex dynamics, emphasizing the need for time-resolved measurements.