Non-linear rheology and fracture in polymer-based viscoelastic fluids

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The mechanical behavior of viscoelastic fluids can be probed by impacting at high Reynolds number, a drop of the fluid on a solid target. The collision of a low viscosity liquid drop against a target, of size comparable to that of the drop, results in the formation of a thin liquid sheet that extends radially in air, and then retracts due to the air-liquid surface tension [1,2]. In this talk, we will show that richer phenomena occur with visco-elastic fluids. We use various self-assembled transient networks made of surfactant assemblies reversibly linked by a small amount of telechelic polymers [3,4]. Those networks behave as Maxwell fluids, whose characteristic relaxation time and elastic plateau can be tuned by the sample composition and the nature of the telechelic polymer. Our data are quantitatively compared with results obtained with viscous liquids of viscosities comparable to the zero-shear viscosities of the viscoelastic networks in order to elucidate the viscous and elastic contributions in the process of sheet formation and destabilization. We will discuss how the relaxation time of the viscoelastic network system plays a crucial role in the destabilization of the sheet. In particular, we will show that polymer-based networks with long relaxation times compared to the timescale of the experiment lead to thin sheets with very peculiar features, such as cracks, due to the interplay of viscous and elastic effects (figure, bottom row). By contrast, when the characteristic relaxation time is short or comparable to the timescale of the experiment, purely viscous effects dominate (figure, top row).

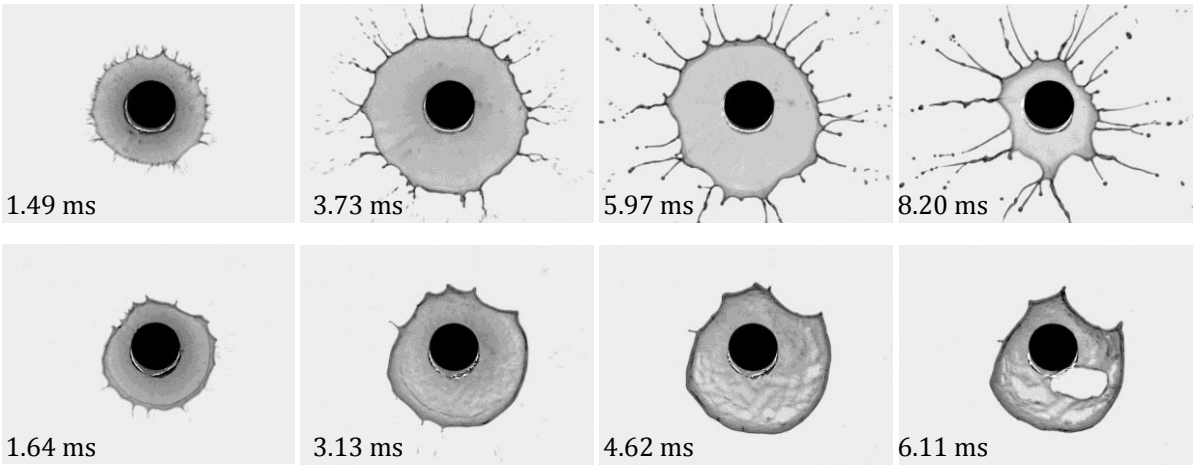

Figure: Time evolution of liquid sheets made of a viscous liquid (top) and of a viscoelastic fluid (bottom). The times indicated correspond to the time elapsed since the drop has impacted the target (shown as the black disk, diameter 6 mm)

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