

# From rheology to phonon-like energy transfer: the unexpected properties of confined liquids

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Rheology has rapidly grown as the tool for analyzing and characterizing the mechanical response of a fluid or material submitted to shear stress. However, it is also a young discipline with considerable room for improved descriptions of the properties of fluids and liquids. Rheology is based on the non-slip hypothesis. This hypothesis was established in the 19th century despite important observations of well-known scientists like Navier who noticed that water flows three to four times more slowly near glass than near copper.

Today, the development of microfluidics and nanofluidics reminds us that non-slip is an assumption, that interfacial stress transfer is crucial when dimensions decrease ( $\leq 1$  mm), and that the interfacial mechanism remains largely undiscovered.

By optimizing interfacial conditions, we show that the viscoelastic response of various fluids can be improved of several decades higher. Furthermore, we show, a quarter of a century after the pioneering work of Derjaghin at few micron scale [1], and using a conventional rheometer equipped with wetting surfaces that the elastic shear modulus no longer vanishes at low frequencies but becomes finite, revealing the elastic nature of confined liquids, which are mistakenly considered viscous at all scales [1,2]. The existence of a finite shear elasticity represents a paradigm shift. Shear elasticity involves long-range interactions that are absent from molecular theories requiring new theoretical models that are emerging [3-7]. Shear elasticity propagates transverse waves as a low-modulus solid would, paving the way for the discovery of new non-equilibrium properties such as the ability to convert energy into flow or deformation in non-equilibrium thermal states where the temperature variation can be positive or negative (fig. 1)[6-8]. The thermomechanical coupling challenges liquid flow as a dissipative process, that, in contrast, calls for a "phononic" energy transfer governing confined liquid flows [4, 9, 10].

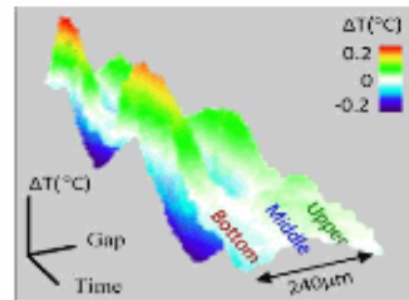


Fig. 1: By applying a low-frequency oscillatory shear strain ( $\sim$ Hz), the liquid emits a modulated synchronous thermal signal. 3D presentation of a real-time snapshot of the temperature distribution in a  $240 \mu\text{m}$  glycerol gap over two oscillatory periods at  $1 \text{ rad/s}$  from [10].

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