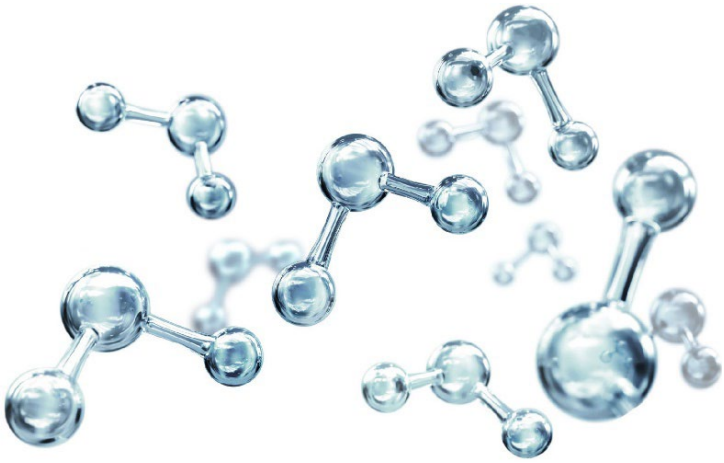
Seminar

CMWS Centre for Molecular Water Science

14th of December 2023
14:00 h (CET)

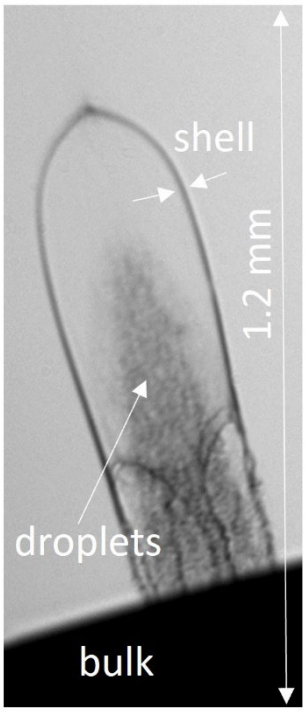
Zoom Virtual Meeting:
https://tuhh.zoom.us/j/82631283465
Meeting-ID: 826 3128 3465
Password: 978444



Sascha Epp

Max-Planck-Institut für Struktur und Dynamik der Materie
Center for Free-Electron Laser Science CFEL

A challenge for molecular interaction: Rubber-like elasticity in laser driven small-molecular liquids



When subjected to deformation, Newtonian fluids such as water and glycerol are expected to exhibit viscous behavior. Viscosity characterizes the ability of a fluid to flow. The energy required to deform a viscous fluid to flow is dissipated as heat. A solid-like elastic response, on the other hand, can only be manifested in a liquid if the deformation occurs on very short time scales and below the relaxation time τ_M which can be related to the molecular diffusion time of a single molecule. The signature of elasticity is a recovery of the deformation energy and a 'memory' of the previous shape with restoring forces towards this shape. The lack of such 'memory' is at the heart of the definition of a liquid.

In a recent paper [1], we presented evidence for a rubber-like elastic large strain response in glycerol that completely dominates the free surface flow dynamics of a laser-driven glycerol plume at strain rates as high as 10^6 s^{-1}. The elasticity is present for microseconds and hence several orders of magnitude longer than τ_M. This persistence cannot arise from the tail of a distribution or spectrum of relaxation times around τ_M but appears by somehow frustrating the fast single-molecule dissipation. For times considerably longer than τ_M the existence of this shear elasticity requires long-range correlations typical for solids and incompatible with the short-range interactions associated with Newtonian fluids —a challenge to our current understanding of the liquid state.

[1] M. Kayanattil et al., Proc. Natl. Acad. Sci. **120**, 2017 (2023).