PROBING YIELD STRESS FLUIDS WITH A VIBRATIONAL RHEOMETER

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Low volume fraction colloidal gels can possess small yield stresses that are able to trap particles or bubbles within the matrix indefinitely. At rest, the stress applied to the network by a probe particle is limited by the density difference between the probe and continuous phase materials. However, vibration of the sample is an acceleration that causes the inertial particles to impart a stress on the fluid; the stress that results from a vibration is also a function of the frequency and amplitude of the vibration. The microscale fluid properties around the probe particles can be elucidated by studying the effects of vibration on the sample. While applying a vertical mechanical vibration to the sample (1 to 5 mm amplitude, 10 to 100 Hz), we make use of high speed particle tracking to record particle trajectories and measure strain, yielding, flow, and recovery of various complex fluid networks.

The measurements enable comparison of the suspension and yielding behaviour of complex fluids with similar rheology but greatly varying microstructures, allowing determination of the optimal approaches to stabilisation of various formulations. Dispersions of colloidal microgels, nanofibres, and wormlike micelles are used in different combinations to explore the robustness of disparate structures to repeated perturbations. Measurements are made of local strain, elasticity, yield stress, and sedimentation rate and compared to continuum predictions for yield stress fluids with more homogeneous microstructures.

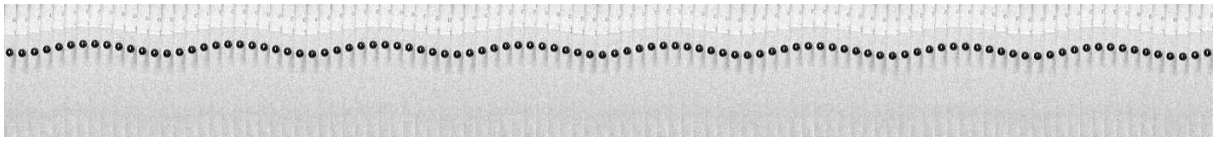

Figure 1 – Time slice images of an individual tracer particle within the oscillating sample. The centre of motion does not change over time for this particle since it is trapped within the network gel.

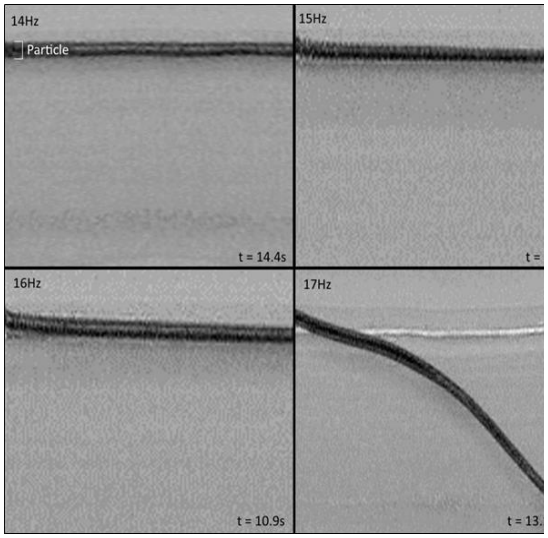

Figure 2 – Stroboscopic time slice images of a tracer particle that is trapped within the network gel at the lowest frequencies but is able to sediment as the fluid yields under the larger stress applied at higher frequencies.

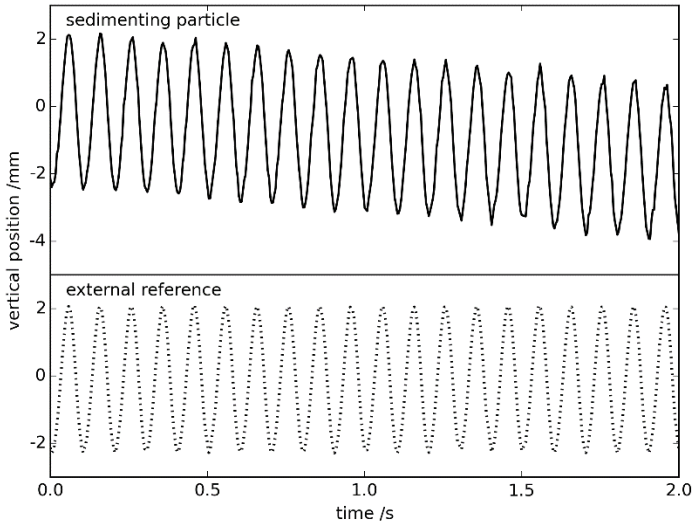

Figure 3 – Digitised trajectory of a sedimenting tracer particle after yielding, along with the trajectory of the external reference marker used as part of the analysis.