nanoSeminar Series 2022

Institute for Materials Science

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Laboratoire de Physique, ENS Lyon

Interpenetration of fractal clusters drives elasticity in colloidal gels formed upon flow cessation (Recent publication)

Thursday, May 12th 2022
13:00 – 14:00

Normal: Seminar Room 115, Hallwachsstr. 3 (HAL)
Pandemic version: https://tinyurl.com/nanoSeminar-GA

Colloidal gels are out of equilibrium soft solids composed of attractive Brownian particles that form a space-spanning network at low volume fractions. The elastic properties of these systems result from the network microstructure, which is very sensitive to shear history. Here, we take advantage of such sensitivity to tune the viscoelastic properties of a colloidal gel made of carbon black nanoparticles. Starting from a fluidized state under an applied shear rate $\dot{\gamma}_0$, we use an abrupt flow cessation to trigger a liquid-to-solid transition. We observe that the resulting gel is all the more elastic when the shear rate $\dot{\gamma}_0$ is low and that the viscoelastic spectra can be mapped on a master curve. Moreover, coupling rheometry to small angle X-ray scattering allows us to show that the gel microstructure is composed of a percolated network of fractal clusters that interpenetrate each other. Experiments on gels prepared with various shear histories reveal that cluster interpenetration increases with decreasing values of the shear rate $\dot{\gamma}_0$ applied before flow cessation. These observations strongly suggest that cluster interpenetration drives the gel elasticity, which we confirm using a structural model. Our results, which are in stark contrast with previous literature, where gel elasticity was either linked to cluster connectivity or to bending modes, highlight a novel local parameter controlling the macroscopic viscoelastic properties of colloidal gels.

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I am a research associate at CNRS with an appointment at the Physics Laboratory at ENS Lyon (Lyon, France) since March 2020. I was first appointed at the Centre de Recherche Paul Pascal (2012-1016) before being transferred to the CNRS-MIT Lab in the Department of Civil and Environmental Engineering at MIT (2016-2020). I received my BA (2004) and Msc (2006) degrees from the Ecole Normale Supérieure in Paris and my Ph.D. (2009) from the Physics Laboratory of the Ecole Normale Supérieure in Lyon (France). I succeeded (top 2%) in the prestigious French competitive exam known as the Agrégation in physics and was a lecturer for 5 years at ENS Lyon. I joined the CNRS in 2012, where I have built an independent experimental activity in the field of Soft Matter. I have a longstanding expertise in the rheology of Soft Glassy Materials, e.g., colloidal gels, dense suspensions, and (bio)polymer gels. My main contribution concerns the discovery of long-lived and yet transient shear-bands during the shear-induced fluidization of Yield Stress Fluids. These heterogeneous "soft solids" are key to out-of-equilibrium living organisms and omnipresent in major industries (i.e., food-stuff, personal care, and oil) with applications in flow batteries and cementitious materials. My current research interests include the linear viscoelasticity of gels, the microscale scenario underpinning the power-law creep response in amorphous solids, and the multiscale characterization of heterogeneous materials via indentation.

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