A new colloidal system to tackle long-standing questions in glass formers

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While liquids flow freely and crystalline solids remain in fixed positions with time, glasses are unique because they lie somewhere between these states. In a single snapshot, glass looks as disordered as a liquid, but it has the mechanical properties of a solid. This makes the glass transition simultaneously interesting and difficult to study [1]. It is often explored with dense suspensions of sub-micron colloidal particles, which are easier to probe in experiments compared to single atoms or molecules.

Temperature controls the glass transition of molecular glass formers. For colloids, by contrast, glassiness is ruled by φ, the fraction of the sample volume occupied by the particles. However, changing φ accurately is challenging and involves preparing a new sample for each target state. Recently, we have demonstrated a new experimental approach to control the volume fraction across the colloidal glass transition [2,3]. The method consists in adding to the colloidal suspension thermosensitive "mesogels" of diameter ~100-200 µm, much larger than the colloidal scale, but smaller than the typical macroscopic sample size. Changing temperature by a few °C results in mesogel shrinkage or swelling (Fig. 1). In turn, this modifies the sample volume available to the colloidal suspension and thus its volume fraction. This method will allow one, for the first time, to precisely control and vary at will and *in situ* φ, without changing the particle interactions.

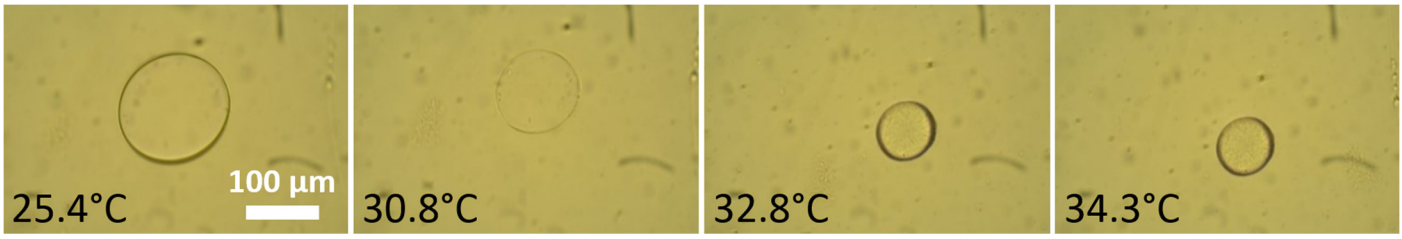

Figure 1: optical microscopy images of a temperature-responsive 'mesogel' immersed in a dense suspension of silica nanoparticles. The nanoparticles have a size of about 40 nm, too small for individual particles to be observable by optical microscopy.

This thesis aims to exploit this new method to address several open questions:

1) How does the rate at which a glass is formed influence its microscopic dynamics and mechanical properties, e.g. ductility *vs* brittleness [4]?

2) Can yielding of a glassy suspension to which a periodic mechanical drive is applied be rationalized as a phase transition with a critical point?

3) How does a local perturbation of φ (e.g. close to a swelling or shrinking mesogel) propagate in space and time, in particular depending on the glassiness of the background colloidal suspension?

The PhD candidate will synthesize mesogels using a microfluidic device and well-established protocols. He/she will use custom setups developed at L2C (space- and time-resolved light scattering coupled to rheology [5]) to measure the microscopic dynamics and the mechanical properties of colloidal glass formers, aiming at elucidating the questions listed above. We seek strongly motivated, self-driven candidates. A background in statistical physics and/or soft matter, optics, or rheology will be a plus.

Local context: The Soft Matter team at the Laboratoire Charles Coulomb (L2C)

The Laboratoire Charles Coulomb (L2C, UMR 5221 CNRS and Université Montpellier, south France) is a multidisciplinary physics laboratory based in the Montpellier Triolet Campus. The soft matter group is composed of 17 permanent researchers and about 8 PhD students and postdocs. In addition to fully equipped chemistry rooms for sample preparation and basic characterization, a wide palette of techniques and setups are available and readily accessible to all team members: (confocal) microscopy, rheology, AFM, static and dynamic light scattering, small angle X-ray scattering…
Several collaborative projects, regular group seminars and a lively and friendly atmosphere make the experience of students and postdocs at L2C enjoyable and profitable.

Grant

Interested candidates should apply on the ADUM web site (https://www.adum.fr/index.pl, thesis n. 41999, dead line: May 9th, 2022) and participate to an interview with a committee from the Ecole Doctorale I2S of Montpellier University (https://edi2s.umontpellier.fr/), to be held between May 23rd and June 8th, 2022.

[1] G. Biroli and J. P. Garrahan, *Perspective: The Glass Transition*, The Journal of Chemical Physics **138**, 12A301 (2013).
[2] J. S. Behra, A. Thiriez, D. Truzzolillo, L. Ramos, and L. Cipelletti, Controlling the Volume Fraction of Glass-Forming Colloidal Suspensions Using Thermosensitive Host "Mesogels," J. Chem. Phys. **156**, 134901 (2022), available on https://arxiv.org/abs/2203.04407
[3] *Mesogels control volume to explore the glass transition*, AIP highlight, https://aip.scitation.org/doi/full/10.1063/10.0010112
[4] W.-T. Yeh *et al*., *Glass Stability Changes the Nature of Yielding under Oscillatory Shear*, Phys. Rev. Lett. **124**, 225502 (2020).
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