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**Timescales in creep and yielding of attractive gels**

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**Introduction**

Yield stress fluids are ubiquitous in our everyday life and encompass a wide range of systems. From dry granular media, slurries, and foams to dense colloidal assemblies and concentrated suspensions of soft colloidal particles such as emulsions, microgels, etc. Despite a huge diversity of compositions and microstructures, the mechanical behavior of these materials is dominated by a critical shear stress \( \sigma_c \), named the yield stress. When submitted to a stress smaller than \( \sigma_c \), these materials all display a solid-like mechanical behavior whereas above \( \sigma_c \), the microstructure is fully reorganized and the yield stress fluid subsequently flows like a liquid, while the shear rate reaches a steady state value.

**Objectives**

The aim of the present work [1] is to investigate thoroughly the yielding dynamics of an attractive colloidal gels (made of carbon black particles) under constant applied shear stress. The stress-induced yielding of such attractive gels has already been studied but only under smooth boundary conditions [2] or with no access to the local fluidization scenario.

**Methodology**

Extensive set of creep experiments by means of a rheometer (MCR301, Anton Paar) coupled to a time-resolved ultrasonic velocimetry technique detailed in [3] are performed on a gel made of attractive carbon black (CB) particles (colloidal soot particles - Cabot Vulcan XC72R of density 1.8) suspended in a mineral oil (from Sigma, density 0.838, viscosity 20 mPa.s) at weight concentrations ranging from 4 to 10% w/w. CB particles interact through a short-range attractive potential and small volume fractions are sufficient to turn the suspension into an interconnected network with solid-like properties.

**Results and analysis**

Under an applied shear stress \( \sigma \), the fluidization of CB gels is shown to involve a previously unreported shear rate response \( \dot{\gamma}'(t) \) characterized by two well-defined and separated timescales \( \tau_c \) and \( \tau_f \). First, \( \dot{\gamma}' \) decreases as a weak power law strongly reminiscent of the primary creep observed in numerous crystalline and amorphous solids, coined the "Andrade creep." We show that the bulk deformation remains homogeneous at the micron scale, which demonstrates that if plastic events take place or if any shear transformation zone exists, such phenomena occur at a smaller scale. As a key result of this study, the duration \( \tau_c \) of this creep regime decreases as a power law of the viscous stress, defined as the difference between the applied stress and the yield stress \( \sigma_c \), i.e. \( \tau_c \sim (\sigma - \sigma_c)^{-\beta} \), with \( \beta=2-3 \) depending on the gel concentration. The end of this first regime is marked by a jump of the shear rate by several orders of magnitude, while the gel slowly slides as a solid block experiencing strong wall slip at both walls, despite rough boundary conditions. Finally, a second sudden increase of the shear rate is concomitant to the full fluidization of the material which ends up being homogeneously sheared. The corresponding fluidization time \( \tau_f \) robustly follows an
exponential decay with the applied shear stress, i.e. $\tau = \tau_0 \exp(-\sigma/\sigma_0)$, as already reported for smooth boundary conditions. Finally, we will also highlight a few features that are common to attractive colloidal gels and to solid materials by discussing our results in the framework of theoretical approaches of solid rupture (kinetic, fiber bundle, and transient network models).

References