Delayed yield in strong colloidal gels

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Colloidal gels are viscoelastic networks formed by microscopic particles bonded together and suspended in a Newtonian fluid. These networks can support their own weight under gravity, yet yield and flow when forced and then regain their elastic character when forcing is removed. This "on demand" solid/fluid/solid transition is key to their utility in 'smart' materials such as tissue scaffolds and injectable pharmaceuticals. The durable yet temporary physical bonds between particles are at the heart of this behavior, and changes in bond strength and attraction range can induce profound changes in their morphology, stability, and mechanical properties. When subjected to fixed stress, the transition from solidlike to liquidlike behavior is a yielding process that is not instantaneous but rather occurs after a finite delay. The delay duration decreases as stress increases, but the underlying microstructural origins were not previously understood. In our recent dynamic simulation studies we elucidated the bond dynamics involved in gel yield when bonds are of order (kT), with the surprising result that fewer than 0.1% of the bonds need break for the gel to yield. In the proposed project, we aim to study whether stronger interparticle bonds will lead to a qualitative change in yield behavior, namely, whether the catastrophic yield predicted by prior phenomenological models is an accurate picture of the structural yield of strongly bonded gels.

For this project, the student will utilize existing simulation and post-processing code in the Zia group, and will run dynamic simulations for a range of strong attractions. Alongside the simulation studies, the student will become familiar with the literature surrounding this topic. The student will then analyze and interpret the macroscopic and micro-mechanical signatures of yield behavior, and determine the degree to which stronger bonds (weaker Brownian motion) affects delay time, failure propagation, and re-solidification.