

**Center for Fluid Mechanics, Division of Applied Mathematics  
Fluids and Thermal Systems, School of Engineering  
Joint Seminar Series**

**TUESDAY – February 19, 2013  
3:00pm  
Barus & Holley, Room 190**

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**Dispersed and kinetically arrested phases in colloids:  
A micro-mechanical perspective**

Complex fluid behavior spans a rich range of states—from dispersed to arrested, and from liquid-like to solid-like behavior. A central theme in the study of such materials is the way they store and dissipate energy. In dispersed colloidal suspensions particles are free to diffuse and rearrange under an imposed flow, but a competition between advective and diffusive forces gives rise to microstructural changes that manifest macroscopically as non-Newtonian behaviors, e.g. shear thinning, shear thickening, and normal stress differences. Under flow, suspensions of simple hard spheres are capable of entropic energy storage; this stored energy may then do useful work when flow ceases. Such entropic recovery occurs over diffusive time scales. On the other hand, in a colloidal suspension where particles also experience attractive forces (on the order of a few  $kT$ , say), the competition between attractive and diffusive forces can lead to kinetic arrest of phase separation and the formation of a colloidal gel; diffusive particle transport is dramatically slowed. Such gels never reach equilibrium because the diffusive rearrangements required to achieve an equilibrium configuration are weak and difficult. In consequence, the bound colloids form a space-spanning network which has an elastic modulus sufficient to sustain its weight under gravity. The gel may yield and flow when forced, but with a higher viscosity than its dispersed-particle counterpart. When flow is stopped, the gel network reforms and elastic behavior returns. This manifestation of non-Newtonian (viscoelastic) behavior suggests a different energy-storage time scale than in a dispersed colloidal system. The structure is not stable, however, nor the approach to equilibrium smooth: after long periods of coarsening as a stable network, such gels may undergo sudden and dramatic rearrangements and, ultimately, total macroscopic collapse. I will discuss these themes from a micro-mechanical perspective, connecting the evolving particle microstructure to the rheological material response, using theoretical and computational approaches.