Short Course

Colloidal gels

Multiscale approaches to structure and rheology

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Timetable Monday, March 27, 2017 to Friday, March 31, 2017

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<th>Mon., March 27</th>
<th>Tue., March 28</th>
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Location: École des Ponts ParisTech, 6 et 8 avenue Blaise Pascal – Cité Descartes Champs sur marne – 77455 Marne la Vallée Cedex 2.

Access by RER A: station Noisy-Champs – sortie 3 - Cité Descartes
Access by A4 highway: exit 10 – Marne la Vallée – Champs sur marne – Cité Descartes
For more information, visit www.enpc.fr

Inscription: send an email to xavier.chateau@enpc.fr

Target audience: This is a graduate level seminar and attendees are expected to be familiar with rheology, basic colloid science, and tensor calculus.

Abstract Particulate glasses and gels occur in numerous chemical technologies and products composed of colloids and soft particles. These arrested, non-equilibrium states are found in consumer care products, agrochemicals, coatings, pigments and inks--potentially any product or material in which particles are suspended at high concentration in a fluid phase. Gels occur in part because of the ubiquity of attractive interactions between particles, which can be due to ever present van der Waals interactions, or induced by the presence of non-adsorbing polymer, for example. In industrial and product formulations, the gel yield stress is sufficiently weak so that that materials may be processed or used effectively (they can flow, be diluted, or dispersed) but otherwise remain stable against gravitational consolidation. However, gels are also prone to unusual and highly unpredictable forms of failure, such as catastrophic delayed gravitational sedimentation, a characteristic that threatens the shelf life and spoilage of billions of dollars of products each year. Because of this, colloidal gels have been of long-standing interest to the engineering and scientific community.

Why and how do gels form? What is the relationship between glasses and gels? There is long-standing debate regarding the mechanisms of gel formation, particularly at moderate to high particle volume fractions and relatively weak attractive interactions. This short course will present an overview of gel structure and rheology from the standpoint of a multiscale description of particle interactions, microstructure, microrheology, and macroscopic rheology. Multiscale methods have largely focused on fractal models, but these fail at moderate to high volume fraction. We will discuss recent advances towards understanding these regimes and highlight emerging methods of micromanipulation and microrheology.

Cours éligible à la formation doctorale pour les doctorants de Paris-Est
1. Gel rheology
   a. Elastic modulus
   b. Yielding

2. Attractive suspensions
   a. Equilibrium phases
   b. Non-equilibrium states

3. Strongly flocculated suspensions
   a. Colloidal interactions of strongly flocculated suspensions
   b. Kinetics of flocculation
   c. Quiescent structure of flocculated suspensions – fractal gels

4. Weakly flocculated suspensions
   a. Colloidal interactions of weakly flocculated suspensions
   b. Structure of weakly flocculated suspensions and gels

5. Methods for characterizing micro-scale structure and dynamics
   a. Scattering
   b. Microscopy
   c. Dynamics of fractal gels
   d. Dynamics of dense suspensions

6. Micromanipulation and particle interaction measurements
   a. Surface and colloidal force measurements
   b. Laser tweezers
   c. Mechanics of colloidal bond rupture
   d. Bond mechanics of strongly flocculated suspensions

7. Microrheology
   a. Probe-based methods
   b. Continuum and non-continuum limits
   c. Local mechanics of gels

8. Multiscale models of gel rheology
   a. Strong gels and the fractal model
   b. Failure of fractal models and motivation for new multiscale models
   c. Cluster gels

9. Gel structure under shear
   a. Compaction
   b. Startup of steady shear
   c. Thixotropy