Schedule for the 5th Mid-Atlantic Soft Matter workshop, November 20, 2009

Johns Hopkins University, Department of Physics-Astronomy, Levering Hall

8:30 am
Registration and Breakfast

9:20 am
Opening Remarks

9:30 am
Jerry Gollub (Haverford College, U. Penn)
Dynamics of Swimming Algae Cells and the Fluid Motion they Produce

10:05 am
Sound-bite Session I

10:45 am
Coffee Break

11:15 pm
Banahalli Ratna (NRL)
Functional Liquid Crystalline Nano Colloids

11:40 am
Sound-bite Session II

12:20
Lunch

1:50
Douglas Durian (U. Penn)
Jamming of Soft Spheres in Microchannels

2:25 pm
Sound-bite Session III

3:05 pm
Break

3:55 pm
Steve Hudson (NIST)
Interfacial Rheology

4:20 pm
Mark Robbins (Johns Hopkins)
Power law correlations and avalanche distributions in quasistatic shear

End of Workshop

Douglas Durian, Department of Physics, U. Penn
Jamming of Soft Spheres in Microchannels
The rheology of materials with a yield stress is difficult to measure because of wall-slip and shear-banding effects. To circumvent this, we use a novel microfluidic method in which stress vs position is determined from force balance and strainrate vs position is determined from high-speed video microscopy. The resulting stress vs strain-rate measurements have a wide dynamic range, including high strainrates at low Reynolds number and hence no inertial instabilities. We apply this method to soft thermoresponsive NIPA microgel beads, whose volume fraction may be easily varied both above and below random close packing by a change in temperature. The results may be collapse per the prescription of Olsson and Teitel, based on simulation of the bubble model, but with different exponents. This supports to the notion that jamming has the character of a phase transition, and that behavior is determined by distance from criticality.

Jerry Gollub , Deptartment of Physics, Haverford College, U. Penn
Dynamics of Swimming Algae Cells and the Fluid Motion they Produce
Algae cells produce a large amount of the world's oxygen. They move around using two flagella whose beating can be either synchronous or asynchronous. When synchronized, the cell swims in a gentle helical path. When asynchronous, the cell undergoes a sharp turn, which can affect its nutrient gain or help to avoid predators. The cell is apparently able to switch between these two states (2). The origin of cell diffusion has thus been determined for algae cell swimmers for the first time. A cloud of these swimming cells also mixes the surrounding fluid (3). Tracers in the fluid undergo an enhancement in their Brownian motion that gives a surprising self-similar probability distribution of displacements consisting of a Gaussian core and also exponential tails. The effect of oscillatory flagellar beating on the mixing process is emphasized.(4)

(1) Work supported by the BBSRC (REG), a Leverhulme Trust Visiting Professorship (JPG), and NSF Grant DMR0803153 (JPG).

(2) Marco Polin, Idan Tuval, Knut Drescher, J.P. Gollub, and Raymond E. Goldstein, "Chlamydomonas swims with two "gears" in a eukaryotic version of run-and-tumble locomotion", Science 24 July 2009. A Perspective by Roman Stocker and William M. Durham appears in the same issue: "Eukaryotic flaggelar synchronization: tumbling for stealth?"

(3) Kyriacos C. Leptos, Jeffrey S. Guasto, J.P. Gollub, Adriana I. Pesci, and Raymond E. Goldstein, "Dynamics of enhanced tracer diffusion in suspensions of swimming microorganisms", submitted to Physical Review Letters.

(4) I am indebted to a talented group of collaborators in Ray Goldstein's group at Cambridge, and to my postdoctoral associate Jeffrey Guasto at Haverford.

Steven D. Hudson, Complex Fluids Group, NIST
Interfacial Rheology
Multiphase liquid systems are essential to everyday life, e.g., foods, pharmaceuticals, cosmetics, oil recovery, biology etc. The morphology, stability and performance of such systems depend on dynamic interfacial properties and mass transfer processes. Therefore techniques have been and are being developed to measure these properties. Typical methods for such measurements often employ simpler flows and larger drops/interfaces than those encountered in typical processing applications. Since limiting mass transfer mechanisms (diffusion and interfacial kinetics) are governed by drop size, experimentation at length scales typical of those encountered in applications is desirable. We have implemented a microfluidic approach that probes this size range. By measuring the dynamics of particle tracers and of drop motion and deformation, the interfacial tension and mobility of oil/water interfaces may be determined in a single experiment. A remarkable correlation between the tension and mobility is found, and we anticipate that future modeling of these results will also yield interfacial viscosity. To demonstrate the use of modeling to determine material coefficients, we investigate the extraction of surfactant from droplets into the continuous phase. A shift from diffusion-controlled mass transfer to a regime where ad-

sorption / desorption kinetics at the interface become limiting is verified for small drop sizes (tens of microns). By calculating the dynamics of extraction, we experimentally determine all four of the interfacial sorption rate constants. Our microfluidic approach thus facilitates measurement of mass transfer kinetics and Marangoni effects, using industrially-relevant flows and drop sizes.

Banahalli Ratna, Naval Research Labs

Functional Liquid Crystalline Nanocolloids

We have developed a new class of functional organic nanocolloids composed of liquid crystal molecules. Liquid crystals provide several advantageous properties and their incorporation into nanocolloids can be utilized for chemical and biological defense. Liquid crystals by their very nature provide spontaneous molecular order and self-assembly. This inherent order can be used to control the distribution of other miscible components, such as fluorescent chromophores, within the nanocolloid. In addition, the liquid crystal molecules can be designed to be responsive to external fields. The combination of the molecular order and responsiveness to external fields can be combined to create novel multi-functional nanomaterials.

Nanocolloids are synthesized using mini-emulsion technique - a two-phase approach that utilizes chloroform to encapsulate the hydrophobic liquid crystal molecules in an aqueous medium using a surfactant. Thermal polymerization with the concomitant evaporation of chloroform stabilizes the liquid crystal nanoparticles for use in both aqueous and dry environments. We have demonstrated the ability to tune the fluorescent emission signature of liquid crystal nanocolloids under single wavelength excitation by controlling the aggregation number of a highly fluorescent chromophore. These fluorescent nanoparticles are capped with surfactant molecules that provide functional chemical groups for conjugation of biomolecules. The long term stability, small size, intense fluorescence with large emission Stokes shift, and ease of bioconjugation open a wide range of applications in biological labeling and bioimaging.

More recently we have incorporated monomeric, voltage responsive liquid crystal molecules into the nanocolloids and studied its effect on the shape of the particle. Altering the monomeric component within the nanocolloids has allowed us to demonstrate the ability to tune the mechanical properties. By applying an external electric field to the nanocolloids, we have observed the reorientation of the molecules within the nanocolloids. These external field responsive nanoparticles can lead to a wide range of detection and decontamination capabilities relevant to both chemical and biological defense.

Mark Robbins, Department of Physics and Astronomy, Johns Hopkins

Power Law Correlations and Avalanche Distributions in Quasistatic Shear

The nature of correlations in the local deformations within sheared systems have been studied using simulations. To model generic amorphous materials we use a bidisperse mixture of different size particles interacting with Lennard-Jones or harmonic potentials. To make the material more brittle, the initial bonds are made stronger than bonds formed after plastic rearrangements. The first part of the talk will contrast the behavior of brittle and ductile systems. The second part of the talk will examine the steady state behavior of ductile systems. Long range spatial correlations lead to a diffusion constant that diverges with system size. The curl of the displacement field, which describes local shear, is shown to exhibit power law spatial correlations. Both the prefactor and the exponent describing these correlations have a strong angular dependence. Deformation occurs through a series of rapid rearrangements. These avalanches or "earthquakes" have a power law distribution of sizes. The power law appears to be insensitive to the form of the potential and the dimensionality of the system. Inertia plays a crucial role in producing this scaling behavior, which is not present in overdamped systems.

Session I

1. Maeva Tureau (University of Delaware)
   Phase Behavior Exploration in ISM Triblock Copolymer-Homopolymer Blends in the Styrene-rich Network Phase Window
2. Xinli Wang (The Johns Hopkins University)
   Transport properties of Brownian particles confined to a narrow channel by a periodic potential
3. Pushkar Lele (University of Delaware)
   Hydrodynamic coupling of multi-particle ensembles near a surface.
4. Yun Liu (NIST Center for Neutron Research)
   Formation of the Dynamic Clusters in Concentrated Lysozyme Protein Solutions
5. JeongJae Wie (University of Delaware)
   Non-Einstein-like Viscosity in Polymer-Nanoparticle Solution
6. Myung Han Lee (University of Pennsylvania)
   Microfluidic Fabrication of Stable Nanoparticle-Shelled Microbubbles
7. Daniel J. Beltran-Villegas (Johns Hopkins University)
   Tunable depletion attraction in equilibrium and non-equilibrium colloidal crystallization via sedimentation
8. Jorge A Bernate (Johns Hopkins University)
   Partition Induced Vector Chromatography in Microfluidic Devices
9. Zexin Zhang (university of pennsylvina)
   Dynamical heterogeneities in attractive colloidal glass
10. Ronald Jones (NIST Polymers Division)
    3-D Structure of Nanostructured Polymer Films using R-SANS
11. Sudeep Dutta (Georgetown University)
    Spatial Inhomogeneities in Sheared Compressed Emulsions
12. Shengfeng Cheng (Johns Hopkins University)
    Contact line dynamics of diffuse fluid-fluid interfaces
13. Ted Brzinski (University of Pennsylvania)
    Settling of Dispersions of Hard Spheres in Viscoelastic Fluids
14. Richard Arevalo (Georgetown University)
    Size-dependent rheology in type I collagen gels

Session II

1. Armstrong Mbi (Georgetown University)
   Rheology of Bi-dispersed "glassy" silica

2. Daniel Sanborn (Anton Paar)
   Application & Technological Developments In Soft Matter Characterization Instrumentation

3. Dan Richman (JHU)
   Studying DNA-polymer complexes with scattering

4. Matthew Lohr (University of Pennsylvania)
   Helical Packings and Phase Transformations of Soft Spheres in Cylinders

5. Joel Rovner (Johns Hopkins University)
   Anisotropic Stokes Drag on Cylinders in Nematic Liquid Crystals

6. hongyu guo (johns hopkins university)
   Thermoreversible gel formation and aging in concentrated nanoparticle suspensions

7. Adam Roth (University of Pennsylvania)
   Liquid Fraction and Coarsening in 2D Foams

8. Julie Albert (University of Delaware)
   Effect of Surface Energetics on Block Copolymer Thin Film Ordering

9. Piotr Habdas (Saint Joseph's University)
   Direct imaging of colloidal suspensions with short-range attractive potential

10. Basavaraja Madivala Gurappa (University of Delaware)
    Phase behavior of Vesicle-polymer mixtures

11. Shibu Abraham (Georgetown University)
    Triplet radical-pair recombinations of 1-(4-methylphenyl)-3-phenyl-2-propanone in reaction cavities of poly(alkyl methacrylate) films

12. Elizabeth Knowlton (Georgetown University)
    NIPA Particles: the Volume Fraction Problem

13. Lynn Daniels (University of Pennsylvania)
    Pressure Scaling on Approach to Jamming in a Gas-Fluidized Bed

Session III

1. Dr. Jennifer Kelly (NIST)
   Investigation of thermally responsive block copolymer thin film morphology using gradient libraries

2. V. Ajay Mallia (Department of Chemistry, Georgetown University, DC)
   Gelation and thixotropic properties of organogelators based on (R)-12-hydroxystearic acid derivatives

3. Wouter Ellenbroek (University of Pennsylvania)
   Calcium-induced lipid domains: how to glue charge with charge

4. Lisa Manning (Princeton University)
   How do mechanical interactions give rise to surface tension in biological tissues?

5. Raghavendra Devendra (Johns Hopkins University)
   Separation Mechanism in Microfluidics

6. Jorge Bernate (Jonhs Hopkins University)
   Partition Induced Vector Chromatography in Microfluidic Devices

7. Todd J Taylor (NIH)
   Protein structure analysis using Delaunay tessellation

8. Ke Chen (University of Pennsylvania)
   Vibrational density of states in two-dimensional colloidal systems

9. Kerstin Nordstrom (University of Pennsylvania)
   Dynamical Heterogeneities in a Sheared Colloidal System

10. Jung Min Kim (University of Delaware)
    Effect of particle size on the nanostructure, phase behavior, and dynamic oscillatory rheology of a model nanoparticle gel

11. Ting Ge (Department of Physics & Astronomy, the Johns Hopkins University)
    Bauschinger effect in glassy polymers

12. Charles Thomas (University of Pennsylvania)
    Clogging in a Tilted Silo

13. Peter Yunker (University of Pennsylvania)
    Observation of the Disorder-Induced Crystal-to-Glass Transition

14. Frederick R. Phelan Jr. (NIST)
    Modeling of Nanotube Separation using Field-Flow Fractionation Techniques