Schedule for the 7th Mid-Atlantic Soft Matter workshop, June 10, 2010

The Univeristy of Pennsylvania, Materials Research Science and Engineering Center.

8:00 am
Registration and Breakfast

8:50 am
Opening Remarks

9:00 am
Dennis Discher (U. Penn): *Soft Matter approaches to Drug Delivery Shapes and Stem Cell Induction*

9:40 am
Sound-bite Session I

10:40 am
Coffee Break

11:00 am
Christopher Stafford (NIST): *Stiffness, strength, and ductility of nanoscale thin films and membranes*

11:40 am
Sound-bite Session II

12:30 pm
Lunch

1:40 pm
Daniel Blair (Georgetown): *The perplexing world of Collagen Rheology*

2:20 pm
Sound-bite Session III

3:10 pm
Break

3:30 pm
Michael Bevan (Johns Hopkins): *Landscape Models for Colloidal Crystallization Dynamics*

4:10 pm
Sound-bite Session IV

4:30 pm
Break

4:40 pm
Andrea Liu (U. Penn): *Jamming of ellipsoids*

End of Workshop

Andrea Liu, Dept. of Physics, U. Penn
Jamming of ellipsoids
At the heart of the concept of jamming is the idea that the transition to mechanical rigidity has universal aspects in a broad class of materials. This suggests that much can be learned by studying simple systems. For the simplest model–packings of frictionless, repulsive, athermal soft spheres–studies have shown that jamming is intimately related to the geometry of the contact network. At the onset of jamming with increasing density, the contact network is isostatic; i.e., the average contact number per particle is precisely the minimum needed to constrain motion. This property leads to a length scale that diverges at the isostatic jamming transition; the existence of this length scale provides a rationale for understanding why the onset of rigidity might be universal. However, when the particle shape is perturbed away from a sphere–as in ellipsoids–the transition to rigidity is no longer isostatic. Nevertheless, I will argue that for ellipsoids there is a new length scale that diverges at the jamming transition, suggesting that the critical nature of the jamming transition may have origins that are broader than isostaticity.

Christopher Stafford, Polymers Division, NIST
Stiffness, strength, and ductility of nanoscale thin films and membranes
Nanoscale thin films or membranes supported by flexible substrates, such as artificial skin, flexible electronics, sensors and photovoltaics, are often the critical performance elements in technologies essential to solving the Grand Challenges of the 21st Century. Degradation of these elements, whether catalyzed by chemical, structural or other phenomena, is frequently manifested in mechanical failure. In order to better predict the mechanical robustness of such devices, it is absolutely imperative to measure the full spectrum of mechanical behaviors in thin-film geometries.

In this presentation, I will describe a methodology based on wrinkling and cracking to simultaneously measure the stiffness, fracture strength, and onset fracture strain of nanoscale thin films and membranes supported directly on a soft, flexible substrate. These descriptors of the thin film are equivalent to Youngs modulus, tensile strength, and elongation at break for bulk materials. These three key material properties yield a near comprehensive representation of the thin-film mechanical behavior, as we show by tracking the embrittlement upon chlorination of thin polyamide nanolayers used in reverse osmosis membrane technology. The increased brittleness of polymer membranes upon continuous chlorine attack makes them easier to fracture, ultimately resulting in the failure of membrane performance.

Daniel Blair, Dept. of Physics, Georgetown
The perplexing world of collagen rheology
Soft and biological materials often exhibit disordered and heterogeneous microstructure. In most cases, the transmission and distribution of stresses through these complex materials reflects their inherent heterogeneity. We have developed a set of techniques that provide the ability to apply to quantify the connection between microstructure and local stresses in the presence of a globally applied strain by combining confocal microscopy with rheology. We subject biopolymer matrices to uniform shear deformations while measuring the transmission of stress at the boundaries. I will describe our recent results on the size dependent nonlinear rheology of type I collagen networks. We utilize a modified version of traction force microscopy to help elucidate how the material microstructure determines the bulk material properties. I will present our preliminary results that suggest that the signatures of yielding in these materials follow a universal form.

Michael Bevan, Dept. of Chem. and Biomol. Eng., Johns Hopkins

Landscape Models for Colloidal Crystallization Dynamics

Understanding concentrated colloidal dynamics in the presence of different pairwise interactions and external fields provides a basis to predict the temporal evolution of colloidal microstructures in diverse phenomena including suspension rheology and colloidal crystallization. However, a theory of concentrated colloidal dynamics does not yet exist that rigorously includes both the statistical mechanics (free energy changes) and fluid mechanics (hydrodynamic interactions) associated with changing microscopic configurations. In this talk, we present an order-parameter based Fokker-Planck (FP) model that captures the non-equilibrium dynamic evolution of initially disordered colloidal fluid configurations into colloidal crystals. Using measured depletion and electric field mediated potentials, we employ Monte Carlo simulations to identify order parameters for crystallization and to construct free energy landscapes. We show that an FP based analysis of Brownian Dynamic (BD) and Stokesian Dynamic (SD) simulated trajectories produces the same free energy landscapes. We then use the FP analysis to extract "diffusivity landscapes" from BD and SD simulations to understand the role of multi-body hydrodynamic interactions. Finally, we demonstrate the use of dynamic landscape models to predict first passage times between different microscopic states and to experimentally control the dynamic assembly of colloidal crystals.

Dennis Discher, Dept. of Chem. and Biomol. Eng., U. Penn.

Soft Matter approaches to Drug Delivery Shapes and Stem Cell Induction

From viruses to tissue matrices, biology is filled with remarkable polymeric structures that motivate mimicry with goals of both clarifying and exploiting biological properties and principles. Several distinct systems will be described from our explorations of nano-shape and/or flexibility in bio-function and recognition. First, filamentous viruses and proplatelets inspire development of worm-like polymer micelles that reveal nano-therapeutics can deliver better if non-spherical in shape [1]. The results have motivated new material mimetic designs with charge and patterns [2]. Second, soft tissues and matrices are measured and imitated in their elasticity using polymeric hydrogels, which demonstrating the potent influence of matrix elasticity on basic processes such as stem cell differentiation [3] while motivating novel liquid crystal approaches to in-cell structure [4]. The results collectively illustrate the potential for a productive interplay between materials biophysics and biomolecular engineering.

[1] Y. Geng, P. Dalhaimer, S. Cai, R. Tsai, M. Tewari, T. Minko, and D.E. Discher. 2007. Shape effects of filaments versus spherical particles in flow and drug delivery. Nature Nanotechnology 2: 249-255 (2007).

[2] D.A. Christian, A. Tian, W.G. Ellenbroek, I. Levental, P.A. Janmey, A.J. Liu, T. Baumgart, D.E. Discher. Spotted vesicles, striped micelles, and Janus assemblies induced by ligand binding. Nature Materials 8: 843?849 (2009).

[3] A. Engler, S. Sen, H.L. Sweeney, and D.E. Discher. Matrix elasticity directs stem cell lineage specification. Cell 126: 677-689 (2006).

[4] A. Zemel, F.Rehfeldt, A.E.X. Brown, D.E. Discher, and S.A. Safran. Optimal matrix rigidity in the self-polarization of stem cells. Nature Physics 6: 468 - 473 (2010).

Soundbite Talks: *MASM7*

Session I

1. Raghavendra Devendra (Johns Hopkins University)
   Separation Mechanisms in Anisotropic Microfluidic Devices
2. Oleg Kogan (University of Pennsylvania)
   Effect of generalized boundary conditions on stability of jammed packings
3. Thomas Lamkin (University of Pennsylvania)
   Finite-Difference Time-Domain (FDTD) Analysis of Spiky Gold Nanoshells
4. Jennifer Rieser (University of Pennsylvania)
   Cohesive forces in a 2D granular system
5. Jai A. Pathak (MedImmune/AstraZeneca)
   Really complex fluids: moleculary crowded protein solutions in the bulk and at interfaces
6. Yuli Wei (University of Pennsylvania)
   Dynamic Water Retention in Sandy Soil with Hydrogel Particle Additives
7. Julie Albert (University of Delaware)
   Gradient Methods for Exploring Thin Film Phase Behavior
8. Adam Roth (University of Pennsylvania)
   Coarsening of Two Dimensional Foam on a Curved Surface
9. Shang-You Tee (University of Pennsylvania)
   High Resolution Traction Force Imaging in Live Cells
10. Peter Beltramo (University of Delaware)
    Dielectric Spectroscopy of Nanoparticle Dispersions
11. Huseyin Kurtuldu (Haverford College)
    Flagellar Waveform Analysis of Swimming Algal Cells
12. Jerry Gollub (Haverford College and UPenn)
    Enhancement of Biomixing by Swimming Cells
13. Zahra Fakhraai (University of Pennsylvania)
    Molecular Mobility on the Surface of Glassy Materials
14. Daniel J. Beltran-Villegas (Johns Hopkins University)
    A Smoluchowski Analysis of Confined Single Particle Conservative and Dissipative Interactions
15. Mark Panczyk (University of Delaware)
    Two-dimensional assembly of dumbbells in AC electric fields.
16. Armstrong Mbi (Georgetown University)
    Dynamics of Sheared Glassy Silica using Confocal Rheology

17. Peter Yunker (University of Pennsylvania)
Phonon Spectra, Nearest Neighbors, and Mechanical Stability of Disordered Colloidal Clusters with Attractive Interactions

18. Sumedh R Risbud (Johns Hopkins University)
Minimum distance attained by a sphere moving past a spherical or a cylindrical obstacle

19. Matthew Gratale (University of Pennsylvania)
Density of States of Two-Dimensional Soft-Particle Colloidal Crystal with Hard-Particle Dopants

20. Sudeep Dutta (Georgetown University)
Spatial Characterization of a Sheared Dense Emulsion

Session II

1. Teresa Brugarolas (University of Pennsylvania)
Generation of Amphiphilic Janus Bubbles and Their Behavior at an Air-Water Interface

2. Richard Arevalo (Georgetown University)
Stress Inhomogeneities in Sheared Collagen Networks

3. William Benjamin Rogers (University of Pennsylvania)
Direct measurements and models of DNA-mediated colloidal interactions

4. Elizabeth Knowlton (GEORGETOWN UNIVERSITY)
Packing, Compressibility and NIPA

5. James Swan (University of Delaware)
The steady shear stress rheology of concentrated colloidal dispersions

6. Kenneth Salerno (Johns Hopkins University)
Inertia and Avalanches...

7. Matthew Lohr (University of Pennsylvania)
Dynamics and Rearrangements of Arrested 2D Phases of Attractive Colloids

8. Carrie Street (University of Delaware)
Microstructure, Crystallization, and Rheology of a Model Crystallizing Surfactant System

9. Tim Still (UPENN, LRSM)
The Influence of Surfactants on the Coffee-Ring Effect in Drying Colloidal Suspensions

10. Vibha Kalra (Drexel University)
Experiments and Molecular Simulations in Nanoscale Materials

11. Valeria Garbin (University of Pennsylvania)
Forced nanoparticle desorption from oil-water interfaces

12. Jonathan Bauer (University of Delaware)
Using convective self-assembly techniques to enhance plasmonic effects in photonic applications

13. Joel Rovner (Johns Hopkins University)
Anisotropic Stokes Drag and Dynamic Lift on Cylindrical Colloids in the Nematic Liquid Crystal 5CB

14. Daniel Koch (Georgetown University)
Growth cone biomechanics and substrate rigidity response in peripheral and central nervous system neurons

15. Jillian Emerson (University of Delaware)
Homopolymer Blend/Nanoparticle Organic Photovoltaic Devices

16. Daniel Salas (Princeton University)
The Dynamic Behavior of Nuclear Bodies

17. Charles Thomas (University of Pennsylvania)
Geometry Dependence of the Clogging Transition in a Tilted Hopper

18. Quentin Sherman (Haverford College)
Characterization of Two-Dimensional Granular Shear Flow

Session III

1. Robert Hickey (University of Pennsylvania)
Superparamagnetic Polymersome Assembly

2. Ryan Bradley (University of Pennsylvania)
Molecular modeling of membrane curvature driven by epsin

3. Beatriz E Burrola Gabilondo (Georgetown University)
Optical Traps and Polymer Networks

4. Edward Banigan (University of Pennsylvania)
Migrating T cells perform Levy flights

5. Kwando Tettey (University of Pennsylvania)
Modulating Layer-by-Layer (LbL) Assembly Using a Short Amphiphilic Molecule

6. Prachi Thareja (University of Delaware)
Surfactant Self Assembly

7. Chau Tran (Drexel University)
Nano-engineered Proton and Electron Conducting Materials for Fuel Cell Applications

8. Marina Feric (Princeton University)
   Mechanics of Cell Growth

9. Matthew Shindel (University of Delaware)
   Colloidal Adhesion on Biogenic Surfaces

10. Yile Gu (University of Pennsylvania)
    Spray Layer by Layer Assembly of All-Nanoparticle Thin-Film Coatings

11. Peter J. Collings (Swarthmore College)
    Self-Assembly and Liquid Crystal Properties of an Infrared Dye

12. Kathryn Whitaker (University of Delaware)
    Microrheology of Colloidal Gels and Glasses

13. Whirang Cho (Univeristy of Delaware)
    Identification of Bacteriophage with binding specificity to organic crystals

14. Hyejin Han (University of Delaware)
    Rheological study of printed electronics in and micro-rheology

15. Carl Goodrich (University of Pennsylvania)
    Observing the Length Scale l in Jammed Systems*

16. Michael O'Reilly (University of Pennsylvania)
    Morphology Characterization of PEO-PTMO Copolymer Ionomers

17. Lorenzo Botto (University of Pennsylvania)
    Capillary bond between rod-like microparticles at interfaces

18. Ted Brzinski (University of Pennsylvania)
    Settling of Dispersions of Hard Spheres in Polymeric Fluids

Session IV

1. Francisco Buitrago (Univeristy of Pennsylvania)
   The Morphology of Polyethylene-based Precise Copolymers

2. Gang Feng (Villanova Univeristy)
   Nanomechanical Characterization of the Cement Lines in Bovine Femurs

3. Jamie Ford (University of Pennsylvania)
   Morphology of Sulfonated NEXAR Pentablock Copolymers in Polar Solvents

4. Brenda Sanchez-Gaytan (University of Pennsylvania)
   Spiky Gold Nanoshells

5. Jae-Hong Choi (University of Pennsylvania)
   Morphology and Ion Conduction in Diblock Copolymer and Ionic Liquid Mixtures

6. Jean-Eudes Le Douget (University of Pennsylvania)
   Clogging of colloidal particles in a 2D microfluidic porous media

7. Ke Chen (University of Pennsylvania)
   Structural instabilities and low-frequency modes in colloidal glasses

8. Xi-Jun Chen (University of Pennsylvania)
   Enhanced DNA Binding Capability and Gene Delivery/Regulation Application