Schedule for the 9th Northeastern Complex Fluids & Soft Matter (NCS) Workshop
University of Pennsylvania, Philadelphia PA
May 25, 2018

8:00 am – Arrival & Breakfast (Singh Center for Nanotechnology)
Location: 3205 Walnut Street Philadelphia PA, 19104

8:50 am – Opening Remarks (Sing Center, Glandt Forum, 3rd floor)

9:00 am – Invited Talk I: **Doug Durian** (University of Pennsylvania)
Nonlocal Lubrication Forces and the Sedimentary Jamming Front

9:30 am – Invited Talk II: **Enkeleida Lushi** (Simons Foundation, NYC)
Motion of micro-swimmers in confinement

10:00 am – Short Talk I

10:45 am – Coffee Break & Discussions

11:10 am – Short Talk II

11:50 am – Invited Talk III: **James Gilchrist** (Lehigh University)
Flow-Assisted Particle Assembly for Nanostructured Coatings

12:20 pm – Lunch + Posters

1:40 pm – Short Talk III

2:20 pm – Invited Talk IV: **Becca Thomases** (UC Davis)
Microorganism locomotion in viscoelastic fluids

2:50 pm – Short Coffee Break

3:10 pm – Invited Talk V: **Hao Lin** (Rutgers University)
Universal Timescales in Cell Aggregation

3:30 pm – Short Talk IV

4:30 pm – Invited Talk VI: **Ying Sun** (Drexel University)
The effect of particle wettability on the stick-slip motion of the contact line

5:00 pm – End Workshop/ Final Remarks

Invited Talks

(*Glandt Forum, 3rd Floor Singh Center***)**

1. **Doug Durian** – University of Pennsylvania
Nonlocal Lubrication Forces and the Sedimentary Jamming Front

   Abstract: While much is now known about jamming and the jamming phase diagram, the kinetics of jamming / unjamming transitions is relatively unstudied and difficult to control in applications. To isolate the baseline physics, we consider a phenomenon ubiquitous in particulate suspensions: Sedimentation of grains into a jammed sediment at the bottom of a sample. In particular, we wish to isolate the kinetics of jamming in terms of behavior at the jamming front that moves upwards at constant speed and shape. To begin we formulate a nonlinear partial differential sedimentation equation to describe spatiotemporal changes in concentration for sedimenting particles at low Reynolds number. It is based on two fluid-mediated forces. One is the viscous interaction of a particle with the surrounding suspension, which causes the settling speed to decrease with increasing volume fraction according to an empirical hindered settling function; we constrain its form by a comprehensive data compilation. The other ingredient is a nonlocal lubrication force set by the spatial gradient in the time derivative of volume fraction. It resists change in separation between neighboring particles, and balances gravity in the accumulating sediment. These forces, plus gravity and mass conservation, lead to the sedimentation equation. We report linear response plus asymptotic analysis and numerical solution for the shape of the stationary jamming front between sediment and suspension that moves upwards at constant shape and speed. Due to the nonlocal lubrication forces, the width of the front increases with the volume fraction of the suspension. Further questions regard the nature of concentration fluctuations and dynamical heterogeneities near the front, and how they differ from bulk behavior due to the strong gradient in the average concentration.

2. **Enkeleida Lushi** – Simons Foundation, NYC
Motion of micro-swimmers in confinement

   Abstract: Interactions between motile microorganisms and solid boundaries play an important role in many processes. I will discuss recent advances in experiments and simulations that aim to understand the motion of micro-swimmers such as bacteria, micro-algae or spermatozoa in confinements or structured environments. Our results highlight the complex interplay of the fluidic and contact interactions of the individuals with each-other and the boundaries to give rise to intricate behavior.

3. **James Gilchrist** (Lehigh University)
Flow-Assisted Particle Assembly for Nanostructured Coatings

   Convective deposition of nano- and microscale particles is used as a platform for scalable nanomanufacturing of surface morphologies to control and enhance photon, electron, and mass transport. The fundamental mechanism behind self-organization of these particles is attraction driven by the local capillary interactions and flow steering of particles confined in a thin film of an advancing meniscus. By studying and altering thin film dynamics, we can control morphology and various instabilities that occur during deposition of mono- and bidisperse suspensions. For instance, by adjusting the suspension profile we alter assembly from a particle-by-particle deposition to a pre-organized deposition mode that affects the deposited morphology. Likewise, lateral mechanical oscillatory motion of the substrate alters the mode of deposition increasing the rate of deposition and reducing the sensitivity of the process to fabricate crystalline monolayers and the unique ability to form flow-templated long range thin film FCC 100 colloidal crystals. This process has been successful in fabricating coatings that enable or enhance performance of light emitting diodes (LEDs and OLEDs), dye sensitized solar cells (DSSCs), polymeric and inorganic membranes, and cell capture platforms. Each application, including our goal toward making this an industrially-relevant scalable nanomanufacturing process and continuing our interest in studying the fundamental properties of suspension microstructure and mechanics, will be discussed briefly. Support for this work has come from the National Science Foundation CBET and the Scalable Nanomanufacturing Program, the Department of Energy, and the PA NanoMaterials Commercialization Center.

4. **Becca Thomases** – UC Davis
   Microorganism locomotion in viscoelastic fluids

   Abstract: Many important biological functions depend on microorganisms' ability to move in viscoelastic fluids such as mucus and wet soil. The effects of fluid elasticity on motility remain poorly understood, partly because, the swimmer strokes depend on the properties of the fluid medium, which obfuscates the mechanisms responsible for observed behavioral changes. In this talk I will review some recent results that help us understand how fluid elasticity can both enhance and hinder swimming speed. I will discuss recent work using experimental data on the gaits of the algal cell C. reinhardtii swimming in Newtonian and viscoelastic fluids as inputs to numerical simulations that decouple the swimmer gait and fluid type in order to isolate the effect of fluid elasticity on swimming. In viscoelastic fluids, cells employing the Newtonian gait swim faster but generate larger stresses and use more power, and as a result the viscoelastic gait is more efficient. Furthermore, we show that fundamental principles of swimming based on viscous fluid theory miss important flow dynamics: fluid elasticity provides an elastic memory effect which increases both the forward and backward speeds, and (unlike purely viscous fluids) larger fluid stress accumulates around flagella moving tangent to the swimming direction, compared to the normal direction.

5. **Hao Lin** – Rutgers University
   Universal Timescales in Cell Aggregation

   Abstract: Cell aggregates are best used as model systems to study a wide variety of physiological processes including embryogenesis, cancer metastasis, and wound healing. In the long timescales, they behave like viscous drops with a surface tension analogous to that of liquids. In the short, they possess intricate mechanical properties and are in general viscoelastic. I will discuss mechanical aspects of cell aggregates formed via primarily cadherin-based adhesion. Via extensive experimental measurements, we discover two coupled and universal timescales which are well-preserved across 12 different cells types. We use a rigorous mathematical theory to interpret the results, which reveals intriguing properties on both tissue and cellular levels and suggests strong active regulation on the latter. Further work is needed to connect tension-adhesion coupling of individual cells to the system behavior.

6. **Ying Sun** – Drexel University
The effect of particle wettability on the stick-slip motion of the contact line

Abstract: Contact line dynamics is crucial in determining the deposition patterns of evaporating colloidal droplets. Using high-speed interferometry, we directly observe the stick-slip motion of the contact line *in situ* and are able to resolve the instantaneous shape of the inkjet-printed, evaporating pico-liter drops containing nanoparticles of varying wettability. Integrated with optical profilometry of the deposition patterns, the instantaneous particle volume fraction and hence the particle deposition rate can be directly determined. The results show that the stick-slip motion of the contact line is a strong function of the particle wettability. While the stick-slip motion is observed for nanoparticles that are less hydrophilic which results in a multi-ring deposition, a continuous receding motion of the contact line is observed for the case with nanoparticles that are more hydrophilic which leaves a single-ring pattern. A model is developed to predict the number of particles required to pin the contact line based on the force balance among the hydrodynamic drag, interparticle interactions, and surface tension acting on the particles near the contact line. A five-fold increase in the number of particles required to pin the contact line is predicted when the particle wettability increases from the wetting angle of $\theta \approx 80°$ to $\theta \approx 30°$. This finding explains why particles with greater wettability forms a single-ring pattern and those with lower wettability forms a multi-ring pattern. In addition, the particle deposition rate is found to strongly depend on the particle wettability and varies during the colloidal deposition process. Using a combination of modeling and experiments, the relation between particle wettability, contact line motion, and final deposition morphology is determined.

Short Talks

(*3 minutes each, Glandt Forum)*

- ***Session I – 10:00 am***

Seyyed M. Salili – University of Pennsylvania
Optical stripes in Refracted Index-matched Scanning

Rui Zhang – Saint Joseph's University
Single-particle microrheology of colloidal suspensions

Larry Galloway – University of Pennsylvania
Shearing of attractive particles at an interface

Yimin Luo – University of Pennsylvania
Colloid migration in nematic liquid crystal near wavy boundary

Lenka Kovalcinova – NJIT
Wave propagation in stochastic granular chains with random masses

Matt Harrington – University of Pennsylvania
Characterization of Structural Defects in Elongated Grain Packings: A Machine Learning Approach

Sebastien Kosgodagan Acharige – University of Pennsylvania
Sedimentation of clay suspensions

Maziar Derakhshandeh – Princeton University
Analysis of network formation in Pickering emulsions

Navid Bizmark – Princeton University
Nanoparticles in Multiphase Systems

Larry Romsted – Rutgers University
To Model chemical Reactivity in Heterogeneous Emulsions: Think Homogeneous Microemulsions

Pawel Zuk – Princeton University
Trajectory Looping: A new method for simulating stochastic reaction-diffusion systems

H. Jeremy Cho – Princeton University
Crack this: These particle networks keep healing!

- ***Session II – 11:10 am***

James Pikul – University of Pennsylvania
High Performance hierarchical materials through nanoscale engineering

Thomas Dupuis – Princeton University
Dragonfly wings inspired deployable structures

Mohamed Badaoui – Princeton University
Passive fabrication of elastomer thin films

Jian Xu – Stevens Institute of Technology
Self-cleaning CNT-embedded PPy(DBS) Mesh for Controlled Oil Absorbing and Releasing

Yixuan Sun – NJIT
Optimization for pleated membrane filter design

Wei-Shao Wei – University of Pennsylvania
Self-Assembled Structural Colloids of Nematic Liquid Crystal Polymer and Elastomer

Joel Marthelot – Princeton University
Solid structures generated by capillary instability

Pejman Sanaei – NYU - Courant Institute of Mathematics
Mathematical modeling of microstructured membrane filters: A stochastic approach

Binan Gu – NJIT
Modeling Asymmetry of Membrane Filters with Complex Morphology

Guang Chen – Princeton University
Special Functionalization in Nano-confined Electrokinetics by Polyelectrolyte Brushes

Xun Wang – Columbia University
Cell-Cell Adhesion in Tissue Mechanics

Samaneh Farokhirad – University of Pennsylvania
Quantitative analysis for design and vascular targeting of flexible polymeric nanoparticles

- ***Session III – 1:40 pm***

Paul Salipante – NIST
Effect of confinement on velocity profiles of shear banding fluids

Trevor J. Jones – Princeton University
Fluid-Mediated Elastic Tentacles

Boyang Qin – University of Pennsylvania
Flow resistance & structure of viscoelastic fluids in channel flows

Arsene Pierrot – Princeton University
Ferrofluid Instabilities

Lingzhi Cai – Princeton University
Harnessing Interfacial Instabilities in Polymer Melts

Islam Benouaguef – NJIT
Raindrop induced solutocapillary flow on a saltwater body

Nancy Lu – Princeton University
Make it pop: Flow induced compression of soft particle packings

Siqi Du – Rutgers University
Particulate matter air pollution filtration with single water bridge

Ranjiangshang Ran – University of Pennsylvania
3D elastic instabilities in cross-slot channels

Ali Seiphoori – University of Pennsylvania
Stability of aggregates in the environment: role of a solid bridging mechanism

Jesse Hanlan – University of Pennsylvania
Clog Prediction in Granular Hoppers using Machine Learning Methods

- ***Session IV – 3:30 pm***

Anand U. Oza – NJIT
Antipolar ordering of topological defects in active liquid crystals

David Gagnon – Georgetown University
Universal Properties of Mechanical Energy in Cellular Matter

Jaspreet Singh – University of Pennsylvania
How do passive particles sediment in the presence of E. coli?

Ben Ovryn – Colorado State University
Single molecule tracking of tagged glycans and modeling of beads-on-a-string structures along membrane nanotubes in live cells

Brendan Blackwell – University of Pennsylvania
Swimming, mixing, and transport in 2D time-periodic flows

Miguel Ruiz-Garcia – University of Pennsylvania

Tuning Networks: Dealing with landscapes and local minima

Juliette Sardin – University of Pennsylvania
Sperm swimming in viscoelastic fluids

Steven MT Wei – Princeton University
Intracellular phase separated assemblies of intrinsically disordered proteins

Tianya Yin – Rutgers University
Molecular Dynamics Simulations on the Mobilization of a Deposited Nanoparticle by a Moving Interface

Ying Zhang – Stevens Institute of Technology
Deformation Analysis of Surfactant-Laden Drop under Electric Field

Swapnil Praven – Temple University
Foot geometry and impact kinematics after interactions with granular media

Posters

(1st floor of Singh Center during lunch)

Abbas Fakhari – University of Pennsylvania
Phase-Field Modeling of Complex Fluids using Lattice Boltzmann Methods

Justin Cheung – Stony Brook University
Nanoconfined Polymethylpentene Thin Films: A Model for Interpolymer Adhesion and Substrate – Polymer Interactions

Chris Giuliano – Stony Brook University
Combining CRISPR/Cas9 and a small molecule inhibitor to probe the function of MELK in cancer

Andrew Gunn – University of Pennsylvania
Turbidity Current Rheology

Xiaoyi Hu – Stony Brook University
Viscous wave breaking and ligament formation in microfluidic systems

Nakul Deshpande – University of Pennsylvania
Probing Granular Creep with Dynamic Light Scattering

Joel Lefever – University of Pennsylvania
Environmental conditions affect the plastic deformation of disordered nanoparticle packings

Ruipeng Li – Brookhaven National Lab
Complex Material Scattering (CMS) -a (GI)SAXS/WAXS beamline