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

8:00 am – Arrival & Breakfast

8:50 am – Opening Remarks

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

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

   Coming soon

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.