NCS14 @ NJIT New Jersey Institute of Technology

14th Northeast Complex Fluids and Soft Matter Workshop
Friday, January 15h, 2021
Virtual Meeting

Morning Session I

8:50 – 09:00 AM Welcoming Remarks

09:00 – 09:30 AM **Invited Talk: Jasna Brujic** (New York University)

"*Colloidal Emulsion Folding as a Route to Self-Assembly*"

From a broad perspective, the challenge is to understand how different interactions and driving forces can be combined to produce a useful designed structure. Here, we will use biological molecules, particularly lipids and DNA strands, to functionalize emulsions in order to self-assemble arbitrarily designed structures. This versatile system allows us to control the fluidity, specificity, valency, and logical programming of interactions between droplets, which in turn facilitates the assembly of complex structures, including emulsion polymers, loops and clusters with particular geometries. In particular, we will focus on the sequential self-assembly of linear droplet chains, in which we will pre-program the strength and specificity of the interactions along the chain. Secondary structure formation will be revealed by confocal microscopy over time, in response to temperature cycling, this 'beads-on-a-string experimental model is analogous to protein folding on the molecular scale but provides access to the configurational fluctuations on the droplet scale. Learning the principles of emulsion folding will allow us to design and construct folds that result in complex 3D objects from one-dimensional chains. More ambitiously, we will mimic the process of morphogenesis by using DNA chemical reaction networks to structure assemblies of DNA-labeled emulsion droplets. The ultimate goal will be to create artificial neural networks using emulsion droplets. The droplets can readily be solidified; therefore, they offer a route to hands-off manufacturing of objects with inbuilt hierarchies. The long-term goal is to design sequences in order to build unlikely crystalline symmetries, aperiodic crystals, and disordered structures with desirable optical and mechanical properties.

09:30 – 10:00 AM **Invited Alumni Talk: Pejman Sanaei** (New York Institute of Technology)

"*Flight Stability of Wedges*"

Recent experiments have shown that cones of intermediate apex angles display orientational stability with apex leading in flight. Here we show in experiments and simulations that analogous results hold in the two-dimensional context of solid wedges or triangular prisms in planar flows at Reynolds numbers $Re \sim 10^2$ to $10^3$to. Slender wedges are statically unstable with apex leading and tend to flip over or tumble, and broad wedges oscillate or flutter due to dynamical instabilities, but those of apex half angles between about 40° and 55^{0} maintain stable posture during flight. The existence of "Goldilocks" shapes that possess the "just right" angularity for flight stability is thus robust to dimensionality. We also show that the stability is robust to moderate changes in shape and Reynolds number.

10:00 – 10:25 AM Break

Morning Session II

10:25 – 10:30 AM Introductory Comments

10:30 – 11:10 AM Short Video Session I

1. Nancy Lu (Princeton), "*Forced Imbibition in Stratified Porous Media*"
2. Shima Parsa (Rochester Institute of Technology), *"Permeability modification in porous media"*
3. Joanna Schneider (Princeton), "*Using colloidal deposition to mobilize immiscible fluids from porous media"*
4. Daniel Amchin (Princeton), *"Porous confinement mediates the interplay of chemotaxis and growth driven* expansion"
5. Yogin Patel (Rutgers), *"Structural Characterization of Microporous Nanoparticle Emulsion Thermosets"*
6. Christopher Browne (Princeton), *"Elastic turbulence generates anomalous flow resistance in porous media"*
7. Hamed El Kahza (NYIT), *"On mathematical modeling of erosion and deposition in networks"*
8. Navid Bizmark (Princeton), *"Multiscale dynamics of colloidal deposition and erosion in porous media"*

11:10 – 11:40 AM **Invited Talk: Charles Maldarelli** (City College of New York)

"*Continuum and Molecular Dynamic Studies of The Hydrodynamics of Colloid Particles at a Fluid Interface*"

Colloidal-sized particles (10 nm – 10 µm in size) adsorb onto a fluid interface (i.e. a gas/liquid or a liquid/liquid interface) from the continuous phases surrounding the surface and become trapped due to a reduction in their interfacial energy, forming a two dimensional monolayer. Colloid monolayers adsorbed onto the dispersed phase of emulsions and foams are traditionally used in stabilizing dispersions from coalescence. Emerging technologies focus on the self-organization of colloid monolayers formed on the fluid interface of liquid films on solid substrates. Control over later forces

(e.g. capillary attraction and electrostatic repulsion) allows the formation of 2D crystalline monolayer phases on substrates as templates for materials fabrication, and textured surface topologies for super-hydrophobic surfaces.
The organization of colloids in a monolayer is a balance between the surface forces and the viscous resistance to particle motion along the surface. This presentation focuses on the surface hydrodynamics. A continuum analytical theory is presented for the drag force on a colloid at a vapor/liquid interface as a function of its immersion depth into the liquid phase, and the theory is extended by numerical calculation to colloids on the fluid interface of a thin film. A hydrodynamic theory is also developed for the viscous resistance due to the mutual approach of two colloids, and Brownian dynamics simulations are presented to understand the role of thermal fluctuations and hydrodynamic interactions in the capillary attraction of colloid pairs. Molecular dynamics calculations are detailed for the drag force on nano-sized colloids translating at a vapor/liquid interface, and a significant reduction in drag is obtained as the nanoparticle translates within the finite-width interfacial zone of the surface. These MD calculations are extended to the case of Janus particles moving along the interface, where rotation of the particle allows for pinning of the fluid interface along the Janus boundary.
Experiments are presented to demonstrate how the calculated drag force can be used to accurately model the capillary attraction of two colloids. Experiments measuring the Brownian diffusion coefficient of a colloid at an interface are detailed and used with the drag force calculation to obtain the colloid immersion depth and three-phase contact angle.

11:40 – 12:10 **Invited Talk: Irmgard Bischofberger** (MIT)

"*Instabilities and Flow-Induced Defects in Lyotropic Chromonic Liquid Crystals*"

Lyotropic chromonic liquid crystals in the nematic phase are anisotropic fluids. We exploit this intrinsic anisotropy to probe growth morphology transitions that occur in the viscous-fingering instability. In isotropic systems, this instability produces complex patterns that are characterized by repeated branching of the evolving structure, which leads to the common morphologies of fractal or dense-branching growth. In anisotropic systems, by contrast, the growth morphology changes to dendritic growth characterized by stable needle-like structures. We show that the
morphology transition coincides with the onset of shear-alignment at high shear rates, where the shear forces become dominant over the elastic forces from the nematic potential. Below this critical shear rate, the lyotropic chromonic liquid crystal exhibits a tumbling behavior that leads to the formation of pure twist disclination loops and, surprisingly, to the emergence of chiral domains.

12:10 – 01:00 PM Lunch Break

Afternoon Session I

01:00 – 01:05 PM Introductory Comments

01:05 – 02:00 PM Short Video Session 2

1. Ruben Zakine (NYU), *"Swimming droplets interacting with their own path"*
2. Carlos Diaz (MIT), "*Slope, opal self-assembly across wide range of length scales*"
3. Anthony Chieco (UPenn), *"Experimentally testing a generalized coarsening model for individual bubbles in quasi-two-dimensional wet foams"*

4. Daniel Chin (NYU Shanghai), "*Droplets on a Wall: Moving Contact Lines with Immersed Boundary Method"*
5. Bruna Favetta (Rutgers), *"Amphiphilic Proteins Lead to Creation of Multi-Phase Condensates"*
6. Kartikeya Nagendra (NYU), *"Cis and Trans E-Cadherin interactions govern crystallization at biomimetic droplet interfaces"*
7. Bryan Llumiquinga (Rutgers), *"Electrospray Deposition of Water with Modified Nozzle"*
8. Mohmmad Shoaib (University of Toronto), "*Microstructure of Na-Montmorillonite (Na-Mt) aqueous suspensions"*
9. Felipe Paiva (Pontifical Catholic University of Rio de Janeiro), *"Shear flow and relaxation behaviors of entangled viscoelastic nanorod-stabilized immiscible polymer blends"*
10. Lingzhi Cai (Princeton), *"Self-Templating Assembly of Drop Lattices"*
11. Alejandro García (University of Buenos Aires), *"Instability of concentrated particle suspensions in oscillatory channel flow"*

02:00 – 02:30 PM **Invited Talk: Nakhiah C. Goulbourne** (National Science Foundation)

"*Mechanics of Materials and Structures Program Overview*"

This talk offers a perspective on current mechanics of materials and structures research and future opportunities to drive technological innovation. Topical program highlights and strategies for proposal development and interfacing with NSF will be discussed. Relevant NSF funding opportunities and new initiatives and trends will be shared.

02:30 – 02:55 PM Break

Afternoon Session II

02:55 – 03:00 PM Introductory Comments

03:00 – 04:05 PM Short Video Session 3

1. Jenna Ott (Princeton), *"To Biofilm or Not To Biofilm: A Competition Between Dispersal and Accumulation"*
2. Selena Chiu (Princeton), *"To Biofilm or Not to Biofilm: The Autoinducer-Yield Parameter For the Extent of Biofilm Formation"*
3. Kathleen McEnnis (NJIT), *"Particle Size Analysis in Blood Plasma"*
4. Jean-Francois Louf (Princeton), *"Under pressure: Hydrogel swelling in confinement"*
5. Aida Lopez Ruiz (NJIT), *"Platinum nanoparticles as therapy for triple negative breast cancer"*
6. Fleurie Kelley (Rutgers), *"Amphiphilic proteins coat membraneless organelles and act as biological surfactants"*
7. Mikhail Smirnov (NYIT), *"Investigating the effects of pleat packing density on a pleated membrane filter*

8. Ismail Erdi Kurtyigit (Rutgers), *"A Novel Method of Aerosolized Particle Filtration Using Liquid Bridges"*
9. Tapomoy Bhattacharjee (Princeton), "*Chemotactic smoothing of collective migration"*
10. Jayesh Ratnam (Rutgers), *"Proximity effects of fibers on the capture efficiency of fibrous filters"*
11. Sarah Park (Rutgers), *"SLED Optimization Study of DNA Solutions"*
12. Abdullah Al Mamun (NJIT), *"Data driven sparse estimation of nonlinear fluid flow from limited sensor data"*
13. Sam Dillavou (UPenn), *"Building a Physical Learning Network"*

04:05 – 04:35 PM **Invited Talk: Paris Perdikaris** (University of Pennsylvania)

"*Bridging Physical Models and Observational Data with Physics-Informed Deep Learning*"

Physical models of many natural and engineered systems are, at best, only partially known; a common setting under which classical analytical or computational tools inevitably face challenges and introduce many sources of uncertainty. Therefore, observational data plays a crucial role, yet our ability to collect them far outpaces our ability to sensibly assimilate it, let alone understand it. Despite their towering empirical success, machine learning approaches are not currently able to extract interpretable information and knowledge from this data deluge. Moreover, purely data-driven methods may fit observations very well, but predictions may be physically inconsistent or implausible, due to extrapolation or observational biases, for example. In this talk we will discuss the foundations of a new family of machine learning methods coined as physics-informed neural networks, that aim to seamlessly bridge this gap by synthesizing incomplete physics-based models with imperfect observational data. Specifically, we will illustrate the mechanisms by which deep neural networks can be constrained to respect fundamental laws of physics, but also highlight certain pathologies and limitations that arise during this process. Strikingly, some of the latter can be addressed by exploring connections to classical methods in numerical analysis and optimization, opening the path to designing more principled algorithms and deep learning architectures that do not simply rely on guesswork. Finally, we will demonstrate the power of these methods across a range of diverse engineering applications, including problems in design optimization, heat transfer, wave propagation, cardiovascular fluid mechanics, and modeling of COVID-19 spread dynamics.

04:35 – 05:05 PM **Invited Talk: Catherine Fromen** (University of Delaware)

"Pulmonary Immune Engineering in the Time of COVID-19"

While respiratory diseases globally number among the top causes of mortality, the field of pulmonary drug delivery has lagged behind other routes of administration in the application of novel therapeutic approaches. Most current inhalers are employed in the treatment of asthma and have yet to effectively address many significant respiratory conditions. As evident from the dearth of COVID-19 therapeutics, a significant need remains to expand inhaled drug delivery beyond the limited number of current therapeutics. Thus, the overall goal of the Fromen lab is to develop personalized aerosol immunomodulatory therapeutics for patients with a wide range of airway conditions, applying concepts of complex fluid dynamics, biomaterials, immune engineering approaches, and additive manufacturing. In this talk, I will highlight recent work from our lab to design 3D-printed, patient specific *in vitro* lung deposition tools that have enabled us to test personalized aerosol delivery to targeted locations in the lung. By controlling the aerosol release position at the mouth inlet, inhaler devices were designed to increase aerosol delivery to specific lobes of the lung. These same *in vitro*

lung models also were used to evaluate homemade facemask designs, quantifying the role of facemask fit on exhaled filtration efficiency. Overall, improved life-sized airway models will continue to promote development of personalized inhaled particulate formulations, with potential future applications for novel treatments for COVID-19, cancer, inflammation, vaccination, and allergy.

05:05 PM Closing Remarks

The NCS14 organizing committee
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