Plenary Speaker Biographies and Abstracts

Plenary 1 - Howard Stone

Two short stories with interfaces: (1) Thin films, an edge, and a novel similarity solution and (2) Nanoscale capillary instabilities and molecular biology

Abstract
I discuss two recent projects combining experiments and theory in different areas of soft matter and fluid dynamics, where interface control the dynamics.

In the first example, we document experimentally the time and (three-dimensional) space variations of the shape of a falling film near the edge of a vertical plate and rationalize the quantitative features using a similarity solution. This example seems unusual since we are able to theoretically show that the shape is described by a nonlinear partial differential equation, involving three independent variables, yet the equation can be reduced by a similarity transformation to a nonlinear ordinary differential equation. The results are in excellent agreement with the experimental measurements. As a second example, we discuss the formation of the spindle in a dividing cell. We report experiments documenting a condensed protein phase on growing microtubules, followed by the Rayleigh-Plateau instability, which produces discrete droplets along a microtubule. We then comment on how the drops drive branching nucleation.

Biography

Howard Stone is the Donald R. Dixon ‘69 and Elizabeth W. Dixon Professor in Mechanical and Aerospace Engineering at Princeton University. His research fields include complex fluids, fluid dynamics and chemical engineering, particularly with regards to heat and mass transport problems. His work has impacted phenomena such as surface tension, fluid rotation, viscosity, the motion of suspended particles and microfluidics. Stone’s recent research also extends to biological systems, including studies surrounding aerosol transport, bacterial biofilms and microtubules. Dr. Stone received his Ph.D. in chemical engineering from the California Institute of Technology in 1988 and in 1989 joined the faculty of the School of Engineering and Applied Sciences at Harvard University; there he became the Vicky Joseph Professor of Engineering and Applied mathematics. Dr. Stone was the first recipient of the prestigious Batchelor Prize in 2008 for best research in fluid mechanics in the last decade, and in 2016 he was awarded the Fluid dynamics Prize by the American Physical Society for his "seminal contributions to our understanding of low Reynolds number flows, microfluidics, interfacial phenomena, and biological fluid dynamics, and for his inspirational contributions to teaching and communicating the beauty and power of fluid mechanics, physics and engineering."

Plenary 2 - Monica Olvera de la Cruz

Colloidal assembly leading to metallicity

Monica Olvera de la Cruz, Northwestern University, m-olvera@northwestern.edu

Abstract
Numerous colloidal crystals have been designed and devised using functionalizing nanoparticles following design rules akin to atomic crystals, where individual colloids behave as atom equivalents (AEs) in lattices. We will review techniques used to achieve single colloidal crystals by exploiting the properties of electrolytes at high salt concentrations and DNA functionalization. We will also describe AEs that behave as electron-equivalents (EEs) when their sizes and grafting density are sufficiently reduced. In mixtures of EEs and AEs, at elevated temperatures the EEs roam within the crystal while also holding the large AEs in specific lattices sites, akin to electron clouds in atomic metals. Additionally, as the temperature decreases, the EEs localize forming compounds. This EE-AE duality produces metallic, intermetallic and compound phases including Frank-Kasper phases. We will describe such localized to delocalized states in different colloidal assemblies, including disparity in charge and size mixtures of oppositely charged particles via a process that resembles sublattice melting in atomic superionics.

Biography

Monica Olvera de la Cruz is the Lawyer Taylor Professor of Materials Science and Engineering; Professor of Chemistry; Professor of Chemical and Biological Engineering; Professor of Physics and Astronomy; Director of the Center for Computation and Theory of Soft Materials; and Deputy-Director of the Center for Bio-Inspired Energy Science.

Research by the Olvera de la Cruz group is centered around the development of models to describe the self-assembly of heterogeneous molecules including amphiphiles, copolymers and synthetic and biological polyelectrolytes, as well as the segregation and interface adsorption in multicomponent complex fluids.

She is a member of the American Philosophical Society, the National Academy of Science (NAS), the American Academy of Arts and Sciences and an American Physical Society (APS) Fellow. She was the recipient of various awards and prizes including the 2017 APS Polymer Physics Prize, the 2010 National Security Science and Engineering Faculty Fellowship, the 2007 Cozzarelli Prize (NAS), a Presidential Young Investigator Award of the National Science Foundation (NSF), an Alfred P. Sloan Fellowship and a David and Lucile Packard Fellowship in Science and

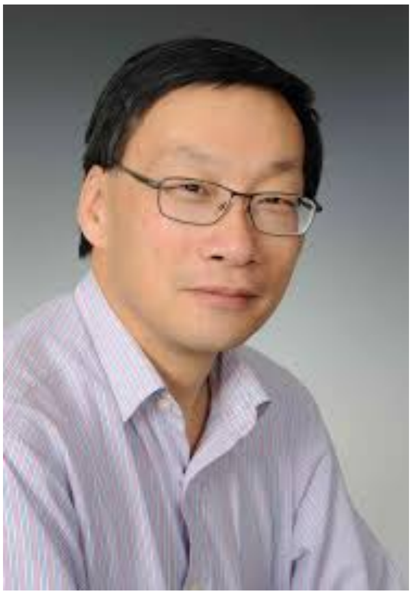
Engineering. She is a member of the US Department of Energy's Basic Energy Sciences Advisory Committee. She has served on the editorial boards of numerous peer-review journals and is a Senior Editor for the ACS Central Science.

Plenary 3 - Wilson Poon

Soft matter physics and the COVID-19 pandemic

Abstract
Much of the science underpinning the global response to the COVID-19 pandemic lies in the soft matter domain. Coronaviruses are composite particles with a core of nucleic acids complexed to proteins surrounded by a protein-studded lipid bilayer shell. A dominant route for transmission is via air-borne aerosols and droplets. Viral interaction with polymeric body fluids, particularly mucus, and cell membranes controls their infectivity, while their interaction with skin and artificial surfaces underpins cleaning and disinfection and the efficacy of masks and other personal protective equipment. The global response to COVID-19 has highlighted gaps in the soft matter knowledge base. I will survey these gaps, especially as pertaining to the transmission of the disease, and suggest questions that can (and need to) be tackled, both in response to COVID-19 and to better prepare for future viral pandemics.

Biography



Wilson Poon holds the Chair of Natural Philosophy in the University of Edinburgh, where he conducts research into soft matter and biophysics, with current focus on the rheology of non-Brownian suspensions and bacterial physics. Much of his recent research is inspired by practical applications — from the flow of molten chocolate to microbial biofouling, which he explores via the Edinburgh Complex Fluids Partnership (ECFP).

Plenary 4 - Jennifer Lewis

Printing Soft Matter in Three Dimensions

Jennifer A. Lewis
Hansjörg Wyss Professor of Biologically Inspired Engineering
John A. Paulson School of Engineering and Applied Sciences & Wyss Institute
Harvard University

Abstract

3D printing enables one to rapidly design and fabricate materials in arbitrary shapes on demand. I will introduce the fundamental principles that underpin 3D printing methods pioneered by our group. I will then describe the design, composition, and rheological properties of colloidal gels, foams, and polymeric inks that we have developed, which are vastly expanding the capabilities of 3D printing. Finally, I will highlight several examples from our recent work, including the fabrication and characterization of colloidal foams, shape-shifting architectures, and soft functional devices.

Biography

Jennifer A. Lewis is the Jianming Yu Professor of Arts and Sciences, the Wyss Professor for Biologically Inspired Engineering in the Paulson School of Engineering and Applied Sciences, and a core faculty member of the Wyss Institute at Harvard University. Her research focuses on 3D printing of functional, structural, and biological materials that emulate natural systems. Prior to joining Harvard, Lewis was a faculty member in the Materials Science and Engineering Department at the University of Illinois at Urbana-Champaign, where she served as the Director of the Materials Research Laboratory. Currently, she directs the Harvard Materials Research Science and Engineering Center (MRSEC) and serves on the NSF Mathematical and Physical Sciences Advisory Committee.

Lewis has received numerous awards, including the Presidential Faculty Fellow Award, the American Chemical Society Langmuir Lecture Award, the Materials Research Society Medal Award, the American Ceramic Society Sosman and Roy Lecture Awards, and the Lush Science Prize. She is an elected member of the National Academy of Sciences, National Academy of Engineering, National Academy of Inventors, and the American Academy of Arts and Sciences. To date, she has co-founded two companies, Voxel8 Inc. and Electroninks, that are commercializing technology from her lab.