2024 FALL SEMINAR SERIES

SCHOOL OF
CHEMICAL ENGINEERING
College of Engineering, Architecture and Technology

North Classroom Building 203 | September 24, 2024 | 10:30 - 11:45 a.m.

Learning Colloidal Interactions, Dynamics, Assembly, and Control

Assembly of colloidal nano- and micro- particles into ordered configurations is suggested as a scalable approach to manufacture microstructured materials with multifunctional properties. Such processes could yield high value-added materials to enable emerging technologies involving coatings, membranes, catalysts, sensors, metamaterials, etc. To solve this engineering challenge, it is essential to understand how Brownian motion, colloidal interactions, collective dynamics, and external stimuli can be controlled to assemble colloidal components into functional materials. A key scientific challenge is understanding how colloidal building block interactions with each other, surfaces, and external fields determine the time evolution of stochastic assembly processes along dynamic pathways via transition and metastable states toward target states.To address open questions and challenges in colloidal assembly, we employ integrated experimental and computational approaches (human and machine learning) to learn interaction potentials, equilibrium and non-equilibrium states, minimal models of transient stochastic dynamic processes, and open and closed loop control policies. In this talk, I will discuss examples from my group's approach to implement open and closed loop control over the assembly of different shaped building blocks into a variety of useful microstructures (glassy, liquid crystalline, crystalline). The key elements that enable formal control of colloidal assembly, include: (1) the ability to quantify microstructures and morphology (sense states), (2) the capability to tune colloidal interactions (actuate state changes), (3) information about non-equilibrium microstructure and morphology evolution after tuning colloidal interactions (stochastic dynamic models), and (4) determining rules for changing colloidal interactions (control policies) based on current and target states (objectives).

Michael Bevan, Ph.D.

We demonstrate real-time control of colloidal assembly and reconfiguration for a variety of colloidal particle shapes and states including hierarchical microstructures. Our approach demonstrates formal control over non-equilibrium dynamic processes in colloidal systems, which we have shown can be extended to diverse materials and control objectives involving non-equilibrium target states, particle navigation, and colloidal devices.

Michael A. Bevan is a Professor of Chemical & Biomolecular Engineering at Johns Hopkins University. He received his Ph.D. from Carnegie Mellon University in 1999. After post-doctoral appointments at the University of Melbourne, Australia, and the Beckman Institute at the University of Illinois at Urbana-Champaign, he joined Texas A&M University in 2002 and Johns Hopkins University in 2008. Bevan's research investigates interactions, dynamics, and structure in interfacial colloidal systems. Bevan is a recipient of a CAREER award and a PECASE from the National Science Foundation, and he was elected as a Fellow of the American Chemical Society in 2016.