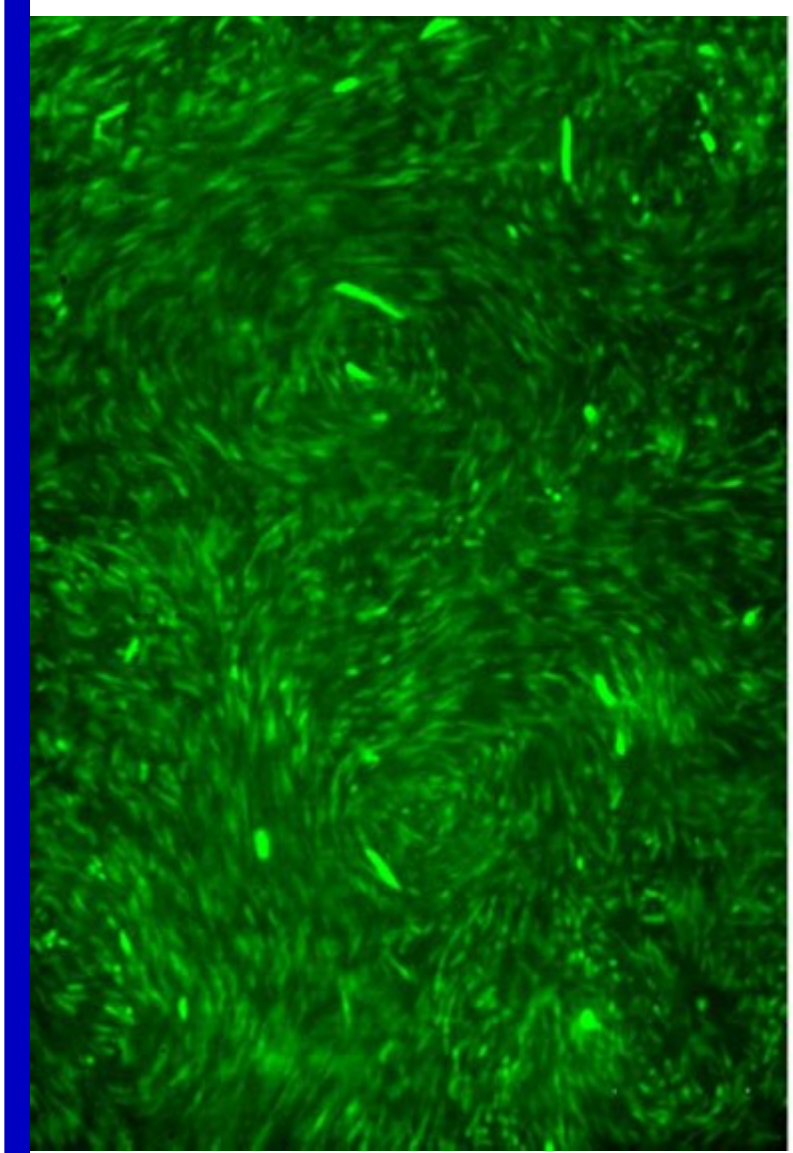
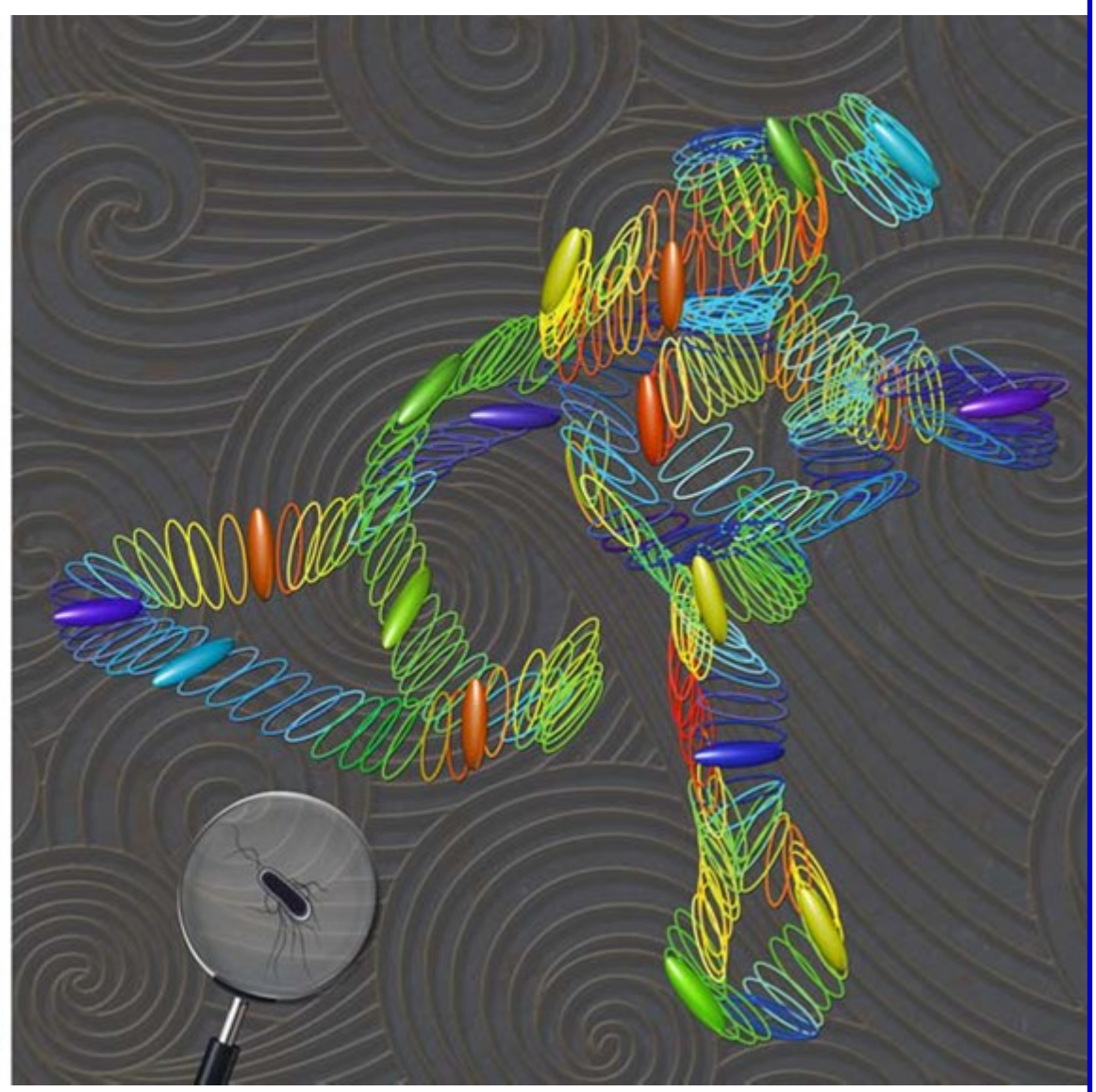
PHYSICS COLLOQUIUM SERIES

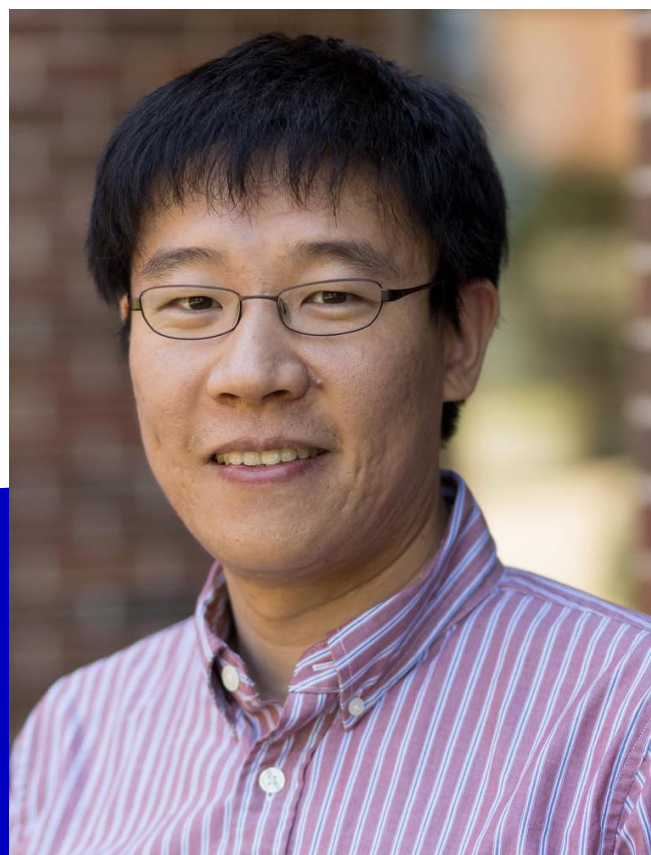
Wednesday, October 31 | 3:00 pm | RNS 210





From Flocking Birds to Swarming Bacteria: A Study of the Dynamics of Active Fluids

Active fluids are a novel class of non-equilibrium complex fluids with examples across a wide range of biological and physical systems such as flocking animals, swarming microorganisms, vibrated granular rods, and suspensions of synthetic colloidal swimmers. Different from familiar non-equilibrium systems where free energy is injected from boundaries, an active fluid is a dispersion of large numbers of self-propelled units, which convert the ambient/internal free energy and maintain non-equilibrium steady states at microscopic scales. Due to this distinct feature, active fluids exhibit fascinating and unusual behaviors unseen in conventional complex fluids. Here, combining high-speed confocal microscopy, holographic imaging, rheological measurements and biochemical engineering, we experimentally investigate the dynamics of active fluids. In particular, we use E. coli suspensions as our model system and illustrate three unique properties of active fluids, i.e., (i) abnormal rheology, (ii) enhanced diffusion of passive tracers and (iii) emergence of collective swarming. Using theoretical tools of fluid mechanics and statistical mechanics, we develop a quantitative understanding of these interesting behaviors. Our study illustrates the general organizing principles of active fluids that can be exploited for designing "smart" fluids with controllable fluid properties. Our results also shed new light on fundamental transport processes in microbiological systems.



Xiang Cheng, Ph.D. is an associate professor of Chemical Engineering and Materials Science at the University of Minnesota. He received his B.S. in Physics at Peking University, his Ph.D. in Physics at the University of Chicago and completed his Postdoc in Physics at Cornell University.