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Life in Complex Fluids

Life immersed in a fluid is nothing unusual for an organism. They cope and take advantage of water or wind currents to move, feed, and reproduce. Many microorganisms (e.g. bacteria, algae, sperm cells) move in fluids or liquids that contain (bio)-polymers and/or solids. Examples include human cervical mucus, intestinal fluid, wet soil, and tissues. These so-called complex fluids often exhibit non-Newtonian rheological behavior due to the non-trivial interaction between the fluid microstructure and the applied stresses. In this talk, I will show how the presence of particles and polymers in the fluid medium can strongly affect the motility (i.e. swimming) behavior of microorganisms such as the bacterium *E. coli*. For bacteria moving in particle suspensions of different (particle) sizes, we find a regime in which larger (passive) particles can diffuse faster than smaller particles: the particle long-time effective diffusivity exhibits a peak in particle size, which is a deviation from classical thermal diffusion. A minimal model qualitatively explains the existence of the effective diffusivity peak and its dependence on bacterial concentration. These results have broad implications on characterizing active fluids using concepts drawn from classical thermodynamics. For swimmers (*E. coli* and *C. reinhardtii*) moving in polymeric liquids, we find that fluid elasticity can significantly affect the run-and-tumble mechanism characteristic of *E. coli*, for example, as well as the swimming speed and kinematics of both pushers and pullers. These results demonstrate the intimate link between swimming kinematics and fluid rheology and that one can control the spreading and motility of microorganisms by tuning fluid properties.

DEPARTMENT OF CHEMICAL & BIOMEDICAL ENGINEERING

GRADUATE SEMINAR SERIES

Where:

Aero-Propulsion, Mechatronics and Energy Building (AME), Room 106

When:

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Dr. Paulo E. Arratia is a Professor of Mechanical Engineering & Applied Mechanics (MEAM) and Chemical & Biological Engineering (CBE) at the University of Pennsylvania. He obtained a B.S. in Chemical Engineering from Hampton University in 1997 and a Ph.D. in Chemical & Biochemical Engineering from Rutgers University in 2003. He worked as a postdoctoral research associate in the Department of Physics at Haverford College and then in the Dept. Physics & Astronomy at the University of Pennsylvania. He is the recipient of the National Science Foundation CAREER Award (2010), the Milton Van Dike Award from the American Physical Society – Division of Fluid Dynamics (2012), the Rutgers University Early Career Distinction Award (2013), and the Christian R. and Mary F. Lindback Award for Distinguished Teaching (2018). He is currently serves as the Associate Chair for Undergraduate Affairs in MEAM and is a Penn Fellow. Dr. Arratia's research focuses on soft-condensed matter, dynamics of complex fluids, biomechanics & biophysics, and microfluidics.