PHYSICAL MATH SEMINAR

Active matter in complex fluids

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ABSTRACT:

Microorganisms often navigate environments with unique and counterintuitive physics, with significant consequences for evolutionary biology and human health. For example, mucus is both viscoelastic and anisotropic, profoundly influencing locomotion. This can be advantageous, as for mammalian spermatozoa swimming through cervical fluid, or detrimental, as with the Lyme disease spirochete Borrelia burgdorferi traversing the extracellular matrix of human skin. Complex fluid phenomena can also enhance or retard a microorganism's swimming speed, and can even change the direction of swimming, depending on the body geometry and the properties of the fluid. Analytical and numerical investigations of swimming in model viscoelastic (Oldroyd-B) and liquid-crystalline (Ericksen-Leslie) fluids will be discussed, emphasizing the critical and often dominant influence of nearby boundaries.

Extending this work, we will then unify a broad spectrum of systems — from active suspensions in Newtonian fluids to individual active particles in confined or bulk complex flows — using three dimensionless parameters. The first is the Deborah number, which compares the timescales of particle activity and environmental relaxation; the second is a similar comparison but of length scales, which we term the Benes number; and the third is the active particle volume fraction. Motivated by this map to navigate towards new research areas, we will describe a mean-field theory describing the dynamics of active suspensions in bulk viscoelastic and anisotropic environments, predicting novel arrested states, traveling waves, and more dramatic thrashing modes.

TUESDAY, APRIL 8, 2025

2:30 PM – 3:30 PM

Building 2, Room 449

MIT MATHEMATICS

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