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University of Miami, Physics Department Colloquium

Date: Wednesday, April 3rd, 2024
Time: 4:00 pm – 5:00 pm
Location: Wilder Auditorium – Room 112, Knight Physics Building

Collective functionalities emerging in microbial active matter

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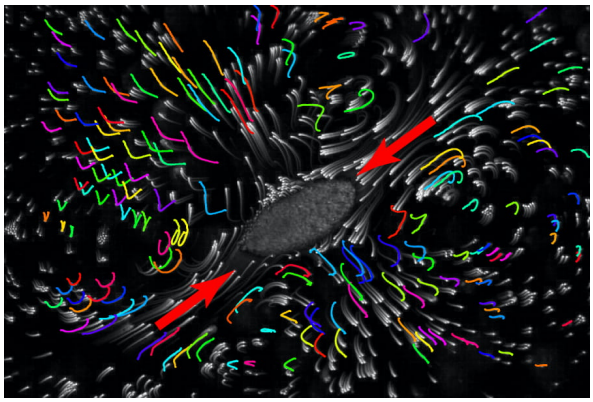
Abstract

Microbes often cooperate to withstand predators and compete even with multicellular organisms. Together, they can achieve functionalities that alone they cannot. However, this puzzle of how biological self-organization emerges from the collective dynamics of individual constituents remains unsolved. In this talk, I will discuss some of these collective functionalities, including communication, navigation, and cooperative nutrient transport. First, we focus on ultra-fast communication through "hydrodynamic trigger waves", signals between cells that propagate hundreds of times faster than their swimming speed [1]. Second, we will explore how bacteria can reorient against flows and contaminate reservoirs upstream [2]. Third, we consider how bacteria generate their own flows to transport nutrients [3], and how "active carpets" like biofilms can lead to enhanced non-equilibrium diffusion [4]. Together, these ideas help us understand emergent self-organization in biological systems and the design space of active materials.



Biography: Dr. Arnold Mathijssen was named '30 under 30' by Scientific American and was awarded the Sir Sam Edwards PhD Thesis Prize for his work in group of Julia Yeomans FRS at the University Oxford (2016). Supported by an HFSP cross-disciplinary fellowship, he moved to the lab of Manu Prakash at Stanford University, where the American Physical Society presented him the Charles Kittel Award (2019). He is now Assistant Professor of Physics & Astronomy at UPenn, co-director of the Penn working group on Environmental and Biological Fluid Dynamics, and chair of the 2024 CUWiP Conference for Undergraduate Women in Physics.

References: [1] Mathijssen et al. "Collective intercellular communication through ultra-fast hydrodynamic trigger waves," Nature 571, 560-564 (2019). [2] Mathijssen et al. "Oscillatory surface rheotaxis of swimming E. coli bacteria," Nat. Commun. 10, 3434 (2019). [3] Jin et al. "Collective entrainment and confinement amplifies transport by schooling micro-swimmers", Phys. Rev. Lett. 127: 088006 (2021). [4] Guzman-Lastra et al. "Active carpets drive non-equilibrium diffusion and enhanced molecular fluxes," Nat. Commun. 12: 1906 (2021).