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Title: Self-organization of bacterial ecosystems: from micro to macro

Abstract:

From bacterial suspensions to bird flocks, the living world is permeated with agents that are able to exert non-conservative forces on their surroundings, and, as such, behave as active particles. Due to their intrinsically out-of-equilibrium nature, these systems exhibit a rich variety of emergent phenomena, such as collective motion, phase separation in the absence of attractive forces, run-and-chase dynamics, and much more.

In this talk, I will discuss how motility regulation in bacterial systems shapes the collective organization of the community. In particular, I will consider quorum-sensing interactions, through which bacteria adapt their motility based on the local density of their peers. Starting from the microscopic dynamics of interacting bacteria, I will show how one can derive the large-scale hydrodynamics of the system, which in turn allows to predict and characterize the emerging phenomenology.

I will show how this framework can be applied to account for the self-organization of bacterial ecosystems, where multiple species of bacteria live and interact in the same environment. By explicitly bridging microscopic and macroscopic dynamics, I will show that, under conditions that are derived explicitly, the system is effectively described by a large-scale equilibrium theory. In turn, this will allow us to account quantitatively, and without fitting parameters, for the rich behaviors observed in microscopic simulations including phase separation, demixing, and multi-phase coexistence. Finally, when the effective-equilibrium condition is violated, I will show the emergence of a wealth of dynamical patterns, corresponding to a run-and-chase dynamics between different bacterial strains.