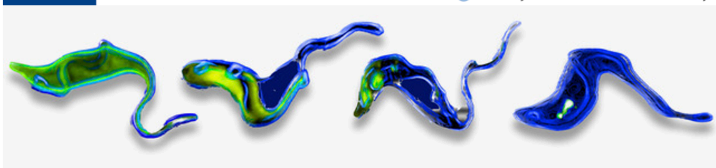

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Active density patterns formation in bacterial binary mixtures

In wild environments, phenotypically diverse microorganisms interact both physically and chemically to give rise to complex community organization [1]. We are interested in the role of physical interactions arising from flagellar motility, a major bacterial trait, in the structuration of such complex communities. This aspect, contrary to biochemical interactions, remains less studied in experiments, despite out-of-equilibrium mechanisms such as motility-induced phase separation (MIPS) offering potential routes for structure emergence [2]. We focused on a minimal system for complex microorganism communities, a binary mixture of motile and non-motile Escherichia coli bacteria. We report a novel non-equilibrium phenomenon by which strong large-scale density heterogeneity patterns of the non-motile bacteria emerge when mixed with motile ones, in a wide physiologically relevant range of concentrations. Experimental results together with quantitative modeling and numerical simulations show that circular swimming of motile cells at surfaces generate recirculation flows that advect the non-motile cells through hydrodynamic interactions, and that sedimentation, by breaking the vertical symmetry of the system, is essential for local non-motile cell accumulation and the emergence of the large-scale density fluctuations. This behavior represents a new type of non-equilibrium self-organization in active bacterial populations, distinct from MIPS-like phenomena, which appears crucial for complex microbial community structuration [3]. We also find that similar physical constraints govern non-motile segregation to the left-hand side when the binary mixture is under flow.

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