Phase separation of active particles coupled to chemical degrees of freedom

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Motility-induced phase separation (MIPS) is a well-studied nonequilibrium collective phenomenon observed in active particles. Recently, there has been growing interest in how coupling the self-propulsion of active particles to chemical degrees of freedom affects MIPS. Studies[1–3] have shown that incorporating chemotaxis and the production or consumption of chemicals by active particles results in various pattern formations, such as arrested phase separation and traveling waves. In this study, we demonstrate that similar phenomena can be induced when active particles consume chemicals and exhibit chemokinesis—where higher chemical concentrations enhance self-propulsion without causing alignment with the chemical gradient. We discover that MIPS is intensified if chemical consumption is proportional to particle density but is suppressed if chemical consumption is closely tied to particle motion. This leads to a wider range of collective behaviors, including arrested phase separation and traveling waves. Our conclusions are based on a hydrodynamic theory derived from a particle-based model via standard methods.

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[3] H. Zhao, A. Košmrlj, and S. S. Datta, Phys. Rev. Lett. **131**, 118301 (2023).