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The Many Faces of Phoretic Active Matter

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Abstract

Phoretic microswimmers, such as Janus colloids and isotropic active droplets, are promising constituents for self-organized active materials. However, the underlying mechanisms governing their self-organization remain unclear, despite numerous experimental observations. Here, we present large-scale simulations of a suspension of isotropic phoretic disks representing active droplets, resolving their many-body, long-range hydrochemical interactions. We observe that they exhibit diverse collective phenomena, including the formation of Wigner-type crystalline solids, melting, gas-like chain formation, active transition and turbulence. Our work reproduces and reconciles seemingly conflicting experimental observations on chemically active systems. Remarkably, altering activity alone induces solid-fluid phase transition and, subsequently, the laminar-turbulent transition of the fluid. These two progressively emerging transitions bring us closer to understanding the parallels between active matter and traditional matter. Our findings will help enhance the understanding of long-range, many-body interactions among phoretic agents, offer new insights into non-equilibrium collective behaviors, and provide potential guidelines for designing reconfigurable materials.

Keywords: Active matter, physicochemical hydrodynamics, active turbulence, microswimmers

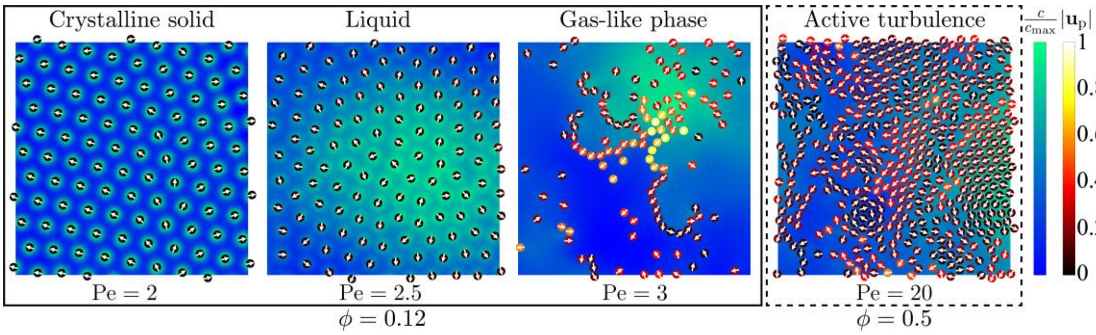

Figure 1. Phoretic disk suspensions exhibit phase transition and laminar-turbulent transition upon varying the Péclet number (Pe) and area fraction ϕ.

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