Hydrodynamic interactions of active matter near boundaries

S. Arman Abtahi[1], Gwynn J. Elfring[1]

[1]Institute of Applied Mathematics, University of British Columbia, Vancouver, Canada

ABSTRACT

Microorganisms and synthetic active particles frequently present in large numbers near boundaries, such as in a petri dish of suspended bacteria or experiments with Quincke rollers near a substrate. Active matter systems have the ability to self-organize into complex dynamic structures when they reach a certain density. These structures are driven by particle-particle and particle-fluid interactions, such as hydrodynamic or electrostatic forces. Confinement can affect self-organization in active suspensions, leading to the formation of vortex-like structures and unidirectional pumping motions. These complex dynamics are distinct from those observed in bulk, such as bacteria forming racetracks and Quincke rollers spinning[1,2,3,4]. This study highlights the importance of understanding the role of boundaries in driving the collective behavior of bacteria and other active matter systems. When suspensions of particles are dense, many-body hydrodynamic interactions take place and far-field approximations can become ineffective. The Stokesian Dynamics method[5] has been extended to simulate dense suspensions of active particles near boundaries using the squirming model[6]. We then use the active SD[7,8] method to demonstrate various examples of interesting dynamics due to hydrodynamic interactions of active particles near a wall[9].

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