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Hydrodynamic Interactions of Micro-Swimmers

Sarah D. Olson*[1] and Lucia Carichino[2]

[1] Worcester Polytechnic Institute, 100 Institute Rd, Worcester, MA 01609, USA, sdolson@wpi.edu
[2] Rochester Institute of Technology, One Lomb Memorial Dr, Rochester, NY 14623, USA, lcsma1@rit.edu

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Sperm are navigating in a complex three-dimensional (3D) fluid environment in order to reach and fertilize the egg. Hence, we investigate how emergent sperm trajectories and flagellar beat forms vary based on proximity to walls and other sperm. We utilize the method of regularized Stokeslets to account for the 3D sperm flagellum immersed in a Newtonian viscous fluid [1,3]. The sperm flagellum is modeled as an elastic rod with preferred curvature and twist, using the Kirchhoff rod model. To examine different types of motility, we explore preferred planar, quasiplanar (helical with unequal radii), and helical beat forms of swimmers that are either in close proximity or far away from a rigid and stationary wall (modeled via a regularized image system). In the case of preferred quasiplanar and helical beat forms, we observe trajectories that can be described as hypotrochoids or f-curves, which significantly change shape with proximity to a wall [1,2]. Attraction of swimmers is observed with planar and quasi-planar beatforms when swimmers were initialized with their centerlines in the same plane (co-planar). Swimmers initialized in free space with planar beat forms and in parallel planes exhibited alternating periods of attraction and repulsion. In contrast, when in close proximity to a wall, these same swimmers would exhibit rolling.

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