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Francois N. Frenkiel Award Talk: Swimming bacteria at complex interfaces

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Flagellated bacteria exploiting helical propulsion are known to swim along circular trajectories near surfaces. Past fluid dynamic studies predict this circular motion to be clockwise above a rigid surface (when viewed from inside the fluid) and counter- clockwise below a free surface. Recent experimental investigations showed that complex physicochemical processes at the nearby surface could lead to a change in the direction of rotation, both at solid surfaces absorbing slip-inducing polymers and interfaces covered with surfactants. Motivated by these results, we use a far-field hydrodynamic model to predict the kinematics of swimming near three types of interfaces: clean fluid-fluid interface, slipping rigid wall, and a fluid interface covered by incompressible surfactants. Representing the helical swimmer by a superposition of hydrodynamic singularities, we first show that in all cases the surfaces reorient the swimmer parallel to the surface and attract it, both of which are a consequence of the Stokes dipole component of the swimmer flow field. We then show that circular motion is induced by a higher-order singularity, namely, a rotlet dipole, and that its rotation direction is strongly affected by the boundary conditions at the interface and the bacteria shape.

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