Negative chemotactic drift induced by surface-driven hydrodynamic interactions

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Many chemotactic bacteria inhabit confined environments and must navigate through fluids confined by solid boundaries or gas–liquid interfaces, which impose constraints on their motility [1]. Swimming near surfaces generates hydrodynamic forces that increase drag, which slows their speed, and impose torques, which steer cells into circular trajectories. While theoretical studies have extensively quantified chemotaxis in bulk fluids [2-5], far less is known about how physical confinement and the resulting hydrodynamic constraints influence chemotactic performance. Here, we derive an analytical expression for the chemotactic drift speed of bacteria subject to surface-induced hydrodynamic torque and we find excellent agreement with numerical simulations. Our analysis reveals the emergence of a drift component that is deflected relative to the direction of the chemical gradient, with the deflection angle determined by the strength and sign of the hydrodynamic torque and the bacterial reorientation rate. This deflection can become sufficiently strong to result in net drift opposite to the preferred chemotactic direction. While our findings reveal a detrimental constraint imposed by environmental geometry, they also raise questions about how bacteria might have evolved strategies to mitigate these effects and maintain effective navigation in confined or complex spaces.

References:

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