CENTER FOR FLUID MECHANICS
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Bacteria in Shear Flow

I present a combined experimental and theoretical analysis of a bacterium exposed to a shear flow. I start by addressing the role of chirality in shear, motivated by the helical shape of some bacterial species (e.g. spirochetes) and of the flagella of all motile bacteria. While non-chiral objects at low Reynolds numbers faithfully follow streamlines, our model based on Resistive Force Theory predicts that the coupling of chirality and shear results in a lift force, which induces a drift perpendicular to the shear plane. We verified this prediction experimentally by exposing spirochetes to a plane parabolic flow in a microfluidic channel and tracking their lateral position by videomicroscopy. This method can be used to separate microscale chiral objects of opposite handedness when shear is larger than rotational Brownian diffusion, providing hope for a straightforward approach for the separation of chiral molecules, of considerable interest in the food and pharmaceutical industries. By tracking individual bacteria in microchannels, we find that shear alters bacterial swimming patterns and in particular reduces their ability to move across streamlines. This results from the bacteria undergoing Jeffery orbits, which bias cell orientation in the direction of the flow and hamper cross-streamline swimming. This can in turn hinder chemotaxis and thus have a significant negative effect on bacteria foraging. Finally, a separate set of experiments shows that bacteria do not alter their swimming behavior in response to shear: nature has apparently not deemed it worthwhile to develop a shear sensor at the micrometer scale.

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APPLIED MATHEMATICS BUILDING
182 GEORGE STREET
ROOM 110
4:00pm