Hydrodynamic coordination of bacterial motions: from bundles to biomixing

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The fluid dynamics of a suspension of swimming organisms are interesting and important both at the scale of the suspension and at the scale of individual organisms. This presentation will address the dynamics at each of these scales.

Experiments with suspensions of swimming cells have revealed characteristic swirls and jets much larger than a single cell, as well as increased effective diffusivity of tracer particles. In this presentation we describe theory and simulations of hydrodynamically interacting microorganisms that may shed some light on the observations [1, 3, 2, 5]. In the dilute limit, simple arguments reveal the dependence of swimmer and tracer velocities and diffusivities on concentration. As concentration increases, we show that cases exist in which the swimming motion generates dramatically enhanced transport in the fluid. A physical argument supported by a mean field theory sheds light on the origin of these effects.

It is well known that many microorganisms propel themselves through their fluid environment by means of multiple rotating flagella that self-organize to form bundles. We examine the dynamics and parameter dependence of this process [4]. The initial stage of bundling is driven purely by hydrodynamics, while the final state of the bundle is determined by a nontrivial and delicate balance between hydrodynamics and elasticity. As the flexibility of the flagella increases a regime is found where, depending on initial conditions, one finds bundles that are either tight, with the flagella in mechanical contact, or loose, with the flagella intertwined but not touching. That is, multiple coexisting states of bundling are found. The parameter regime at which this multiplicity occurs is comparable to the parameters for a number of bacteria.

References

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