Bacteria in liquid crystals: from the swimming mechanism of individuals to collective effects

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Despite the importance of bacterial dynamics in anisotropic environments, very common in biology, many important questions remain unresolved. Water-soluble liquid crystals have proven to be a model system to study the influence of anisotropy on the swimming and space exploration behavior of the micro-swimmers. Recent studies have showed that bacteria are forced to follow the nematic director, inhibiting their intrinsic run and tumble exploration dynamics. We show that, in these highly anisotropic media, bacteria can reverse their swimming direction by relocating at least one flagellum on the other side of their bodies.

Liquid crystals also enable the emergence of new types of collective behavior, such as the spontaneous formation of self-propelled trains of bacteria. We compare these dynamic structures to those formed by the passive self-assembly of particles in liquid crystals and investigate the mechanism enabling their self-propulsion. Finally, we show that more complex collective behaviors emerge when the liquid crystal is confined to spherical liquid crystal droplets and shells, where bacteria are forced to interact with topological defects.