M2 internship - PhD

Persistent random walks: Are bacterial trajectories optimal?

Random walks are a cornerstone of statistical physics. While Brownian motion has long been under scrutiny, there is a growing interest in a different type of motion: persistent walks. Examples abound in active matter and biological world, from self-propelled particles and crawling cells to foraging animals and a plethora of swimming micro-organisms. The statistical properties of such random motions are often unknown yet they play a key role in many vital functions of the organisms and ultimately in their survival.

One striking instance of persistent random motion is the run-and-tumble of bacteria. Bouts of persistent motion ("run") are interspersed with sudden changes of direction ("tumble"). Recent research reveals that bacteria display a fascinating repertoire of swimming patterns, which differ in their run and tumble characteristics. Why? Which benefits come with each swimming strategy?

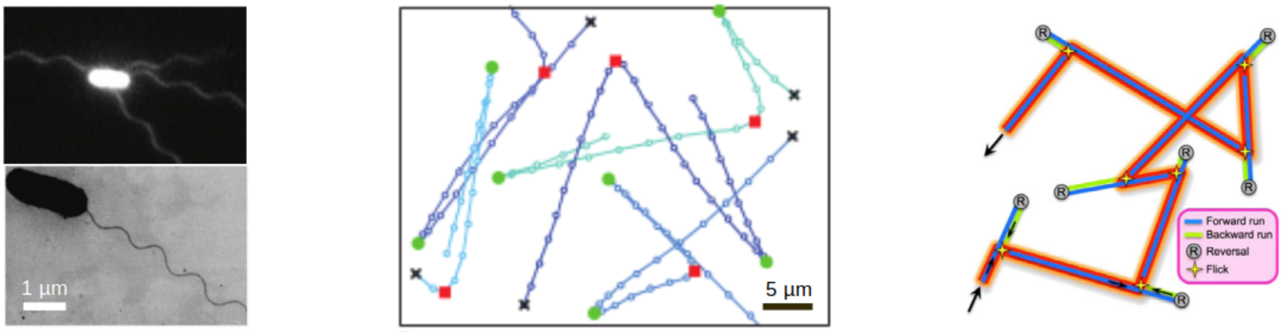

Figure: (Left) Bacteria self-propel by rotating one or several flagella. (Center and Right) Experimentally observed trajectories and schematic swimming pattern. From Son et al, *Nature Physics* (2013).

The goal of the internship is to understand theoretically the statistical properties of run-and-tumble, such as the propagator. The tools to do so are analytical approaches based on the Fokker-Planck equation and numerical simulations. Unveiling the transport properties of various swimming patterns should unveil in which sense they are optimal.

There are many facets of swimming strategies that can be explored in a PhD thesis. These include transport of bacteria in complex environments such as porous disordered media and optimization of informed swimming strategies, where the strategy is adapted dynamically. Besides, the inference of swimming patterns from experimental trajectories deserves some investigation. Finally, collective effects in assemblies of persistent random walkers, such as clustering and clogging, are also of interest.

The ideal candidate would have a strong background in statistical physics and soft or active matter. No background in biology is required.

Keywords: statistical physics, active matter, random walks, micro-organisms.

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