OPTIMAL RANDOM WALKS OF BACTERIA

LABORATORY : Institut Lumière Matière

LEVEL : M2
TEAM(S) : LIQ@INT

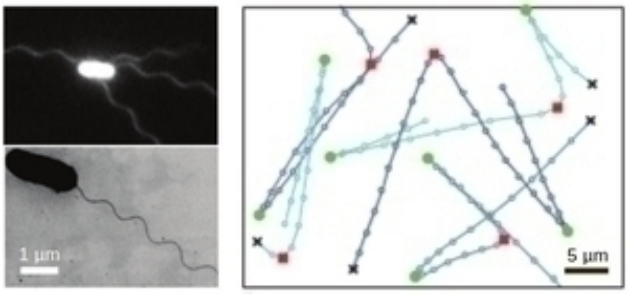
CONTACT(S) : DETCHEVERRY François

CONTACT(S) DETAILS: francois.detcheverry[at]univ-lyon1.fr / Tel. 0472431025

KEYWORD(S) : Active matter / Random walks / Statistical Physics

SCIENTIFIC CONTEXT :

Context. 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.



(Left) Bacteria self-propel by rotating flagella. (Right) Experimentally observed tr

Questions. 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? Why were they selected by billions of years of evolution? In spite of some recent progresses [1], answers remain at the nascent stage.

MISSIONS :

Internship. The goal of the internship is to understand theoretically the statistical properties of **encounter of run-and-tumble**. We will use a combination of numerical simulations and analytical approaches based on the Fokker-Planck equation. A taste for statistical physics and numerical techniques is desirable. No background in biology is required.

PhD thesis. There are many facets of swimming strategies that can be explored in a PhD thesis, from individual properties to collective effects. These include the ability to follow chemical gradients, self-assembly into bands [2] and active clustering. In each of these situations, we will ask whether swimming strategies of bacteria are, in some sense, optimal. This research topic lies at the confluence of **active matter, statistical physics and biophysics.**

OUTLOOKS :

The internship may be pursued as a **PhD** (with grant from "Ecole Doctorale").

BIBLIOGRAPHY :

[1] Universal law for the dispersal of motile microorganisms in porous media, Pietrangeli, Foffi, Stocker, Ybert, Cottin-Bizonne, Detcheverry. Physical Review Letters (2025)

[2] Exact model of aerotactic band: From Fokker-Planck equation to band structure and fluid flow, Detcheverry. PRE (2025)

See also complete offer at http://ilm-perso.univ-lyon1.fr/~fdetcheverry/stage/stageM2these_randomwalks.pdf

published on 28/09/2026