Bacterial exploration under confinement

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E. coli undergo run and tumble kinematics, alternating between 3D swimming and quasi-2D exploration of surfaces (see figure 1). In the absence of boundaries and in a chemically uniform environment, the combination of run and tumble leads to a 3D diffusive process. In numerous practical situations, such as mucus barriers, low-dimensional substrates alters this simple picture and appears as a key to control the large-scale transport and contamination properties. Here, we address this fundamental question by combining experiment and theory using a simple prototypical setup in which bacteria swim in an environment bounded only by the presence of two parallel surfaces separated by a height H .

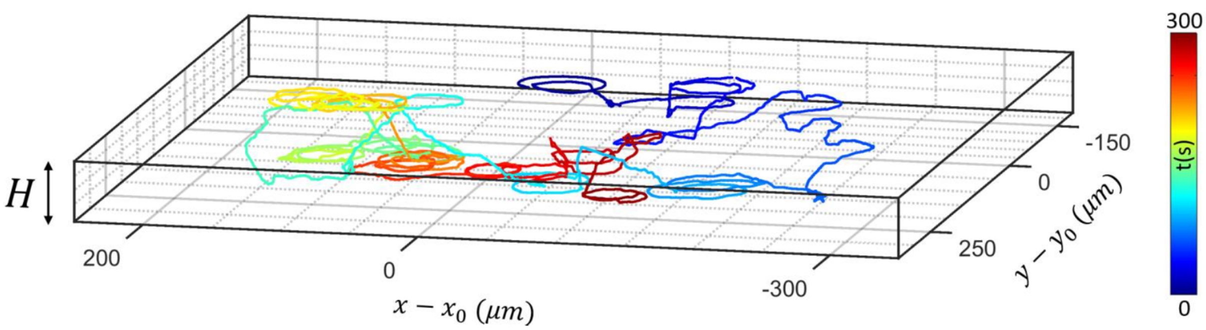

Figure 1. 3D trajectory of duration $T = 300s$ of a E. coli bacterium spreading laterally between two parallel plates separated by a distance $H = 50\mu m$. Motion is circular at surfaces, straight in the bulk, and interrupted by reorientations.

We show that the emerging dispersion process along the plane differs from the boundless limit and explicitly depends on the confinement height as well as on specific features of the surface kinematics. To describe the exploration process, we use the "behavioral variability" (BV) model [1], which has recently been shown to be successful in describing bacterial residence time [3] and backflow contamination [2]. This model incorporates the fluctuations of a slowly varying internal molecular variable, called "the mood", that triggers the run-to-tumble events. In this work we have adapted it to additionally take into account the circular kinematics at surfaces.

Références

1. Figueroa-Morales et al., 3D Spatial Exploration by E. coli Echoes Motor Temporal Variability, *PRX* (2020).
2. Figueroa-Morales et al., E. coli super-contaminates narrow ducts fostered by broad run-time distribution, *Science Advances* (2020).
3. Junot et al., Run-to-Tumble Variability Controls the Surface Residence Times of E. coli Bacteria, *PRL* (2022).