Master 2 Internship

Title: **Cellular dynamics of a one-dimensional bistable system**

Type: **experimental**

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PhD funding (if any): yes

Microbial motility is shaped by interactions with the environment, leading to emergent dynamic behaviours that can be quantitatively described using statistical physics approaches. One particularly intriguing phenomenon is **bistability**, where a system can exist in two distinct, stable states, with stochastic transitions between them occurring under specific conditions. For instance, migrating cancer cells confined in micropatterned domains exhibit bistable occupancy between distinct spatial compartments.[1] Interestingly, such a bistable configuration provides a simplified framework to study transitions and decision-making processes, as it reduces the system's dynamics to a discrete set of states, making it more tractable for quantitative analysis.

When confined to a surface, under a blue light stimulus, microalgae *Chlamydomonas reinhardtii* (CR) can transition from their classical swimming to **gliding**, a one-dimensional motility mode driven by the interaction of flagella with the substrate.[2] Unlike swimming, where flagella undergo cyclic beating, gliding is powered by membrane-associated motor proteins and cytoskeletal elements, leading to a directed movement along the adhered flagella's axis. The mean squared displacement (MSD) of gliding trajectories has shown that this directional motion, enables cells to travel long distances (hundreds of microns) without frequent reversals.[3]

However, our **preliminary results** suggest that under specific light conditions, **gliding motility may exhibit bistability,** with cells stochastically switching between two distinct spatial positions (Figure 1). Rather than displaying continuous, long-run displacement, cells appear to alternate between two preferred locations. Control experiments ensure that the observed bistability is not an artefact caused by unintended light gradients. This challenges the conventional view of gliding as a persistent movement and **raises fundamental questions** about the underlying mechanisms:

(1) What **external factors** induce the symmetry breaking and determine whether gliding is continuous or bistable?

(2) Can this bistable spatial confinement be linked to **intracellular regulatory pathways**?

By employing single-cell tracking, spatiotemporal motility analysis, and light control, this internship will provide **quantitative characterisation of bistable gliding in CR**, uncovering a novel aspect of microbial motility that has not been previously described.

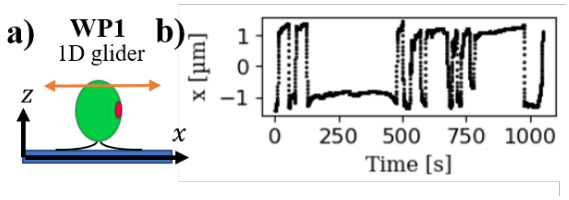

Figure 1: Preliminary data on gliding cells. (a) WP1 investigates gliding motility along the x-axis on a surface (blue). **(b)** Example trajectory of a tracked gliding cell exhibiting bistability, recorded under uniform illumination.

1 Brückner, D. B. *et al. Nat. Phys.* 15, 595–601 (2019); **2** Kreis, C. T. *et al. Nature Phys* 14, 45–49 (2018);
3 Till, S. *et al. Phys. Rev. Res.* 4, L042046 (2022)