INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique de l'ENS
CNRS identification code: UMR 8023
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Internship location: LPENS, Paris
Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Coupling between spatio-temporal oscillations and protein transport in bacterial periplasm

Outer membrane proteins (OMP) mediate the interactions between bacteria and their environment. Their localization is relevant for many physiological processes such as cell infection or biofilm formation. Recent development on the dynamics OMP insertion have shown that OMP are mainly inserted at midcell and then passively advected to the poles. This scenario, where the source of OMP insertion on the outer membrane is located at midcell likely predicts a gradient from the center to the poles. However, a number of OMP have been reported to follow an inverted gradient from poles to cell center. In Gram-negative bacteria, OMPs are first translocated from cytoplasm to periplasm before being inserted in the outer membrane. We recently demonstrated that the periplasmic dynamics of Ag43, an E. coli OMP involved in cell-cell adhesion, is biased towards the poles. Unexpectedly, we showed that the non-trivial dynamics in the periplasm is coupled to the Min system, which oscillates from pole to pole in the cytoplasm. Now, we would like to understand how these two systems (Ag43 and Min) can be coupled while separated by the inner cell membrane. As part of the proposed internship, we will investigate the role of anisotropy in the lipid composition of the inner membrane, more specifically, the role of cardiolipins, which are enriched at cell poles. The internship will mainly consist of performing fluorescence microscopy experiments and image analysis.

The objectives of the proposed internship are twofold:

- Modelling the coupling between the two compartments:

We propose to model that the coupling between cytoplasmic oscillation and periplasmic drift is caused by hydrodynamic interactions mediated by Marangoni flows. In this scenario, Marangoni flows towards the poles will be generated by periodic change of the lipidic composition at cell poles due to cardiolipin-Min interactions.

- Testing experimentally the model hypothesis:

We will measure the dynamics of cardiolipin enrichment at poles to validate that the lipidic composition at cell poles follows Min oscillations. If our hypothesis is valid, the drift should depend on the period of Min oscillations. We will thus measure how the polar location of Ag43 depends on the period of Min oscillations.

Techniques :

- quantitative biology (modeling)
- fluorescence microscopy (TIRF)
- image analysis (python/MatLab)

References :

- Rassam et al, Nature 2015: Supramolecular assemblies underpin turnover of outer membrane proteins in bacteria
- Meindlhumer et al, Nature Communications 2023: Directing Min protein patterns with advective bulk flow

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: YES Theoretical Physics: YES