Biophysical modeling of the auto-assembly driving bacterial DNA segregation

Master 1-2 project (with possibilities to continue with a PhD)

Scientific topic. In bacteria, DNA segregation mainly relies on ParABS systems to faithfully partition DNA molecules at cell division. Our objective is to achieve a holistic, quantitative and molecular understanding of the mechanism driving the main bacterial DNA segregation system by using integrative and multidisciplinary approaches. We will perform **biophysical modeling** using the tools of theoretical physics. Our collaborators in the team of Jean-Yves BOUET (CBI, Toulouse) will perform experiments in genetics and genomics, cell biology and biochemistry to test our predictions. Built on an established collaboration, we intent to decipher the mechanisms that (i) drive the auto-assembly of the nucleoprotein complexes (ParB proteins) involved in the partition of the archetypical ParABS system of the plasmid F in *Escherichia coli.* This part involves a liquid-liquid phase separation of proteins on a polymer, and (ii) the subsequent splitting and positioning of complexes at either side of the division plane (through ParA proteins). This will be done with both non-linear systems and stochastic approaches. We will investigate the cross talk between two dynamic auto-assemblies of ParA and ParB that ensure DNA segregation, and also on the formation and inheritance of membrane-less organelles.

Objectives. This project is at the interface between polymer physics, colloid physics and active matter. We will first consider a Lattice Gas-like (LG) models to characterize the phase transition leading to the formation of the ParBS complexes. We will subsequently embed this LG onto a supercoiled polymer to decipher the rôle of the bridging and polymer compaction on this phase transition. We will finally add a second species of particles to this lattice gas to model the splitting of two equilibrium droplets through the actions of the protein ParB. We will use both numerical and analytical approaches.

Candidate background. The applicant will display an education in theoretical physics and a strong interest in biology. He/she will have skills in numerical simulations (e.g., Monte Carlo methods) and in developing analytical calculations.

Academic context. Thos host team *Complex System and non Linear Physics* is composed by 5 permemanent researcher, PhD students and postdotoral researched working collaboratively on various topic of bacterial processes from the cellular scale with DNA organization and dynamics, genetic translation, flagelar motors motion up to the scale of population dynamics. We have an established collaboration with Jean-Yves BOUET since ten years in Toulouse where experiments will be conducted.

The city & region. The city of Montpellier displays a vibrant atmosphere, with a plenty of cultural and sportive activities. The city has a long history with a beautiful old city center and is surounded with mountains to the North, the Mediterranean sea to the South, while Pyrénées and Alpes are nearby. The weather is mild and sunny most of the year.

Contact and Application. Please send CV and motivation letter to Jean-Charles Walter (jean-charles.walter@umontpellier.fr) researcher at Laboratory Charles Coulomb (Montpellier, France).