PhD thesis fellowship in theoretical biological physics

(start September/October 2023)

Title of the research topic	Theoretical physics modelling of bacterial respiration and charge transfer
Laboratory	**Laboratory Charles Coulomb, UMR5221 CNRS/University of Montpellier, Pl. E. Bataillon, 34095 Montpellier, France**
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Scientific Project: Energy conversion in most bacterial systems involves the use of a transmembrane electrochemical gradient. This gradient is maintained in non-equilibrium thermodynamic conditions by the activity of membrane proton transport proteins linked by lipid electron shuttles, the quinones, which are key elements of charge transport linked to the oxidative phosphorylation process (OXPHOS). This process feeds the charge gradient that drives the activity of transmembrane rotary motors such as F1-Fo-ATP-synthase or the bacterial flagellar motor, fundamental machines for the life of the bacteria.
This project of theoretical biological physics aims to:
1) build a physical model of bacterial respiration from statistical physics and stochastic process theory in order to understand the physical principles of spatial organization (and in particular the origin of phase separation phenomena in nanodomains and their network) and the dynamics of these complexes, the OXPHOS, on the bacterial membrane ;
2) understand how the spatial and temporal organization of OXPHOS complexes and the dynamics of quinones influence the reactivity of these complexes (study of the reactivity of quinones as a function of the organization of OXPHOS) and allow the establishment of the transmembrane electrochemical gradient (e.g. organized vs. scattered distribution of charge sources and sinks networks) ;
3) reveal the functional importance of such a spatio-temporal organization in the biophysics of transmembrane charge transfer at the scale of the single bacterium and of a population of bacteria. In particular, this will help us to understand the function of OXPHOS in nitrate respiration. For this purpose, we will cross physical-mathematical modelling of electron transfer at the bacterial membrane, between OXPHOS complexes via quinones, with data obtained by high spatial and temporal resolution fluorescence microscopy approaches and bacterial metabolism data (coll. A. Magalon and D. Marguet, Marseille).
The theoretical methods employed will make extensive use of statistical physics, the theory of stochastic processes and numerical simulation/calculation.

Research domains: Physico-mathematical and statistical physics modelling of transmembrane charge transport in bacteria, theory of phase transitions in biological systems.
Techniques used: Statistical Physics, stochastic processes, non-linear physics, partial differential equations (PDE), numerical methods for integration of PDE, Monte-Carlo and lattice-gas numerical simulations.
Candidate Profile: Theoretical physicist with a strong interest in the study of complex systems, in particular biological systems, and interested in statistical mechanics, stochastic process physics and nonlinear approaches.
A background in biology will be useful to approach the projects, but not mandatory at the beginning of the thesis. Knowledge of data analysis from super-resolved video microscopy may be useful for the conduct of the project, but not mandatory. Ability to work in an environment of physico-mathematical modellers, but also to interact with experimentalists.

Start of the 3-years PhD project: **September/October 2023.**

Application: Doctoral School "Information-Structures-Systems – I2S:" **https://edi2s.umontpellier.fr/**

Host Team: The PhD student will be a member of the Complex Systems and Nonlinear Phenomena Team - SCPN (Theoretical Physics Axis) at the Charles Coulomb Physics Laboratory. The topic is part of the theoretical physics of biological systems explored during these years by the SCPN Team at the L2C: in particular the physics of stochastic transport and the theory of phase transitions in biological systems.

Scientific environment: Montpellier Area offers a large number of opportunities in biological physics and physics of complex systems: LabEx NUMEV (https://numev.edu.umontpellier.fr/) and MUSE I-SITE Initiative (https://muse.edu.umontpellier.fr/).