Supervisors	Main : Dr. VEESLER Stéphane (CINaM-CNRS Marseille, France) Co- : Prof. KUHN Simon (KUL Leuven, Belgium) Co- : Dr. Alexey RAK (SANOFI Vitry, France)
Contact	stephane.veesler@cnrs.fr
Starting date	2nd semester 2025

PhD proposal

Effect of an electric field or a laser pulse on biomolecule crystallization. Statistical and modelling studies.

Keywords: nucleation / microfluidics / nanoelectrodes / crystals

Studying nucleation of crystals is confronted with the stochasticity of the phenomenon: we do not know where, when, or how many events will emerge. If statistical approaches shed light on this behavior, many uncertainties remain, preventing a fine knowledge and control of this major physical phenomenon, involved in the production of products of pharmaceutical interest (crystal nucleation) as well as in our predictive capacities in meteorology or climatology (droplet and crystal nucleation).

Among the external fields able to limit the stochasticity of nucleation and to offer a more serene framework for its study, intense localized electric fields have demonstrated their ability to control the spatial and temporal localization of crystal, and would greatly benefit from a coupling with statistical approaches as offered by microfluidics.

This project aims at studying the effect of an external field on biomolecules nucleation by applying an electric field or a laser pulse (NPLIN) into a microfluidic set-up. Initially, globular proteins will be studied as model systems.
Specific objectives of the PhD project:
(i) Develop a microfluidic platform for triggering biomolecule crystallization using an external field by developing and integrating nanometric platinum electrodes (tips with a radius of curvature of the order of 10nm) in microfluidic chips or laser pulse.
(ii) Measure statistical data on biomolecule nucleation and provide statistical data to the community.
(iv) Comparison of results obtained with electric field and/or a laser pulse with those obtained with ultrasounds or magnetic fields.
(iii) Modelling the effect of an external field on nucleation of biomolecule, through the interactions with the consortium.

The microfluidic chips, to be designed, will be based on the use of various technologies at our disposal (3D printing, HPLC tubing, mask-free photolithography). The observations of nucleation will be done by optical microscopy and image analysis (ImageJ/Python).

This PhD project is is essentially experimental, and requires work, motivation, meticulousness and inventiveness. The strong supervision reveals the multidisciplinary aspect of the subject,thus requiring organizational skills and autonomy.
Funding will be provided by an MSCA Doctoral Networks program PROCRYSTAL.
The main thesis laboratory, CINaM, is located on the Luminy campus, in the heart of the Calanques National Park in Marseille (France). Visits are planned to the team of Simon Kuhn at the Katholieke Universiteit Leuven (Belgium), as well as discussion on industrial interest with SANOFI Vitry (France).