Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

Laboratory name: ***PHENIX (Physico-chimie des Électrolytes et Nanosystèmes Interfaciaux)***
CNRS identification code: UMR 8234

Internship director'surname: **Pierre ILLIEN (co-supervisors : V. DAHIREL, M. JARDAT)**
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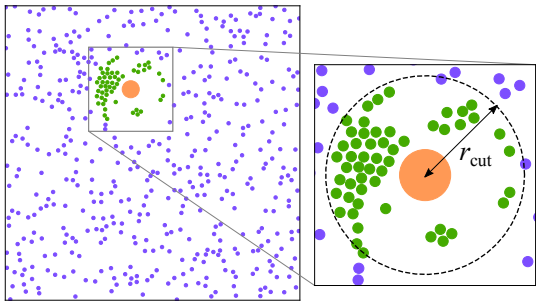
Internship location: Sorbonne Université, campus Jussieu, Paris 5ème

Thesis possibility after internship: **YES**
Funding: École doctorale (to be discussed with the candidate)

Spontaneous propulsion of a particle in a phase-separating environment

Self-propelled particles, like **active colloids**, have been the subject of numerous theoretical and experimental studies [1, 2]. Among the possible routes to locomotion, the design of anisotropic colloids, which interact with self-generated gradients of solute concentration, temperature, or electric fields, has been particularly fruitful. However, there was a more recent interest in the propulsion of **isotropic colloids**. Several examples revealed that **built-in asymmetry** of the colloid is actually not necessary to achieve directed motion over long timescales and that a **spontaneous polarization** of its environment can be sufficient.



In a recent work, we have proposed and studied numerically a model for an isotropic colloid in a bath of solute particles that interact with each other [3]. Within our model, a finite-size **mesoscale phase transition** of a Lennard-Jones fluid can be locally maintained close to the colloid by a **non-equilibrium chemical reaction**. As a result of phase coexistence, **strong density fluctuations** can emerge and considerably enhance the diffusion coefficient of the colloid. The propulsion mode that we have characterized through Brownian dynamics simulations does not require a structural anisotropy of the colloidal particle, as it arises from persistent density fluctuations in its environment. Strikingly, activity is therefore solely driven by **attractive interactions** within the solvent bath.

The goal of this internship is to make progress towards an **analytical model** for the propulsion phenomenon observed in the numerical simulations reported in [3]. A first step would consist in calculating the diffusion coefficient of a tracer particle coupled to a binary suspension that displays **phase separation**. Depending on the taste of the student, the analytical approach will be completed by **numerical simulations** (Brownian and/or molecular dynamics).

References:
[1] P. Illien, R. Golestanian, A. Sen, Chem. Soc. Rev. **46**, 5508 (2017). arXiv:2104.03878.
[2] C. Bechinger et al., Rev. Mod. Phys. **88**, 045006 (2016). arXiv :1602.00081.
[3] J. Decayeux, V. Dahirel, M. Jardat, P. Illien, Phys. Rev. E. **104**, 034602 (2021). arXiv:2103.13244.

Condensed Matter Physics: **YES**	Soft Matter and Biological Physics: **YES**
Quantum Physics: **NO**	Theoretical Physics: **YES**