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

INTERNSHIP PROPOSAL

Laboratory name: PHENIX (Physicochimie des Electrolytes et Nanosystèmes Interfaciaux)
CNRS identification code: UMR 8234
Internship director'surname: **Pierre Illien**
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Internship location**: Sorbonne Université, Campus Jussieu (Paris 5ème)**
Thesis possibility after internship: YES
Funding: YES

Analytical modeling of tracer diffusion in the intracellular medium

Understanding transport of soft matter at small scales is at the heart of many modern scientific challenges. For instance, from a biological perspective, **intracellular self-organization** is governed by the transport of proteins, ions, organelles, or vesicles. Many precise tasks, such as cargo transport or DNA replication, are performed with great efficiency, in spite of the structural complexity of these media, which originates from the nonequilibrium fluctuations which are typically felt at such scales, and from the interactions between the different agents (see Figure).

From a theoretical perspective, such systems are typically represented by a **suspension of interacting particles**, embedded in a solvent that causes their **stochastic motion**. In the systems of interest, the suspended particles generally evolve very **far from equilibrium**. This 'activity' makes them particularly difficult to model, and represents a central challenge in statistical physics. Among the different quantities that can be identified to describe the dynamics of these systems, the properties associated to **tracer particles** are particularly important, as they are key to understand the **kinetics and efficiency of metabolic processes**.

The goal of this internship will be to use an **analytical framework** that we recently developed [1, 2], in order to study the dynamics of tracer particles in confined suspensions made of mixtures of particles, which evolve very far from equilibrium, and which interact via non-reciprocal interactions. We recently showed that these effective interactions could lead to enhanced tracer diffusion: a goal of the internship could be to elucidate the underlying physical mechanisms. Depending on the taste of the candidate, the analytical framework will be completed with **numerical simulations**, using Brownian dynamics codes which are developed within our laboratory.

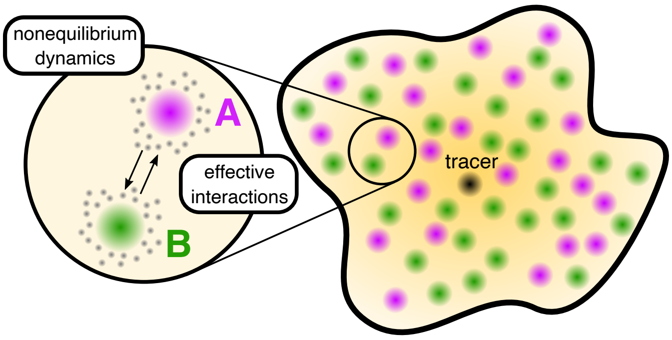

Figure – Mixture of interacting particles, embedded in a solvent that causes their stochastic motion. The nonequilibrium dynamics and effective interactions between particles affect the dynamics of a tracer, whose diffusion coefficient will be the quantity of interest.

References:
[1] M. Jardat, V. Dahirel and P. Illien, arXiv:2209.00929 (2022).
[2] A. Benois, M. Jardat, V. Dahirel, V. Démery, J. Agudo-Canalejo, R. Golestanian, P. Illien, arXiv:2307.05408 (2023)

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