Laboratory of Physical Chemistry of Electrolytes and Interfacial Nanosystems (dir. L. Michot)

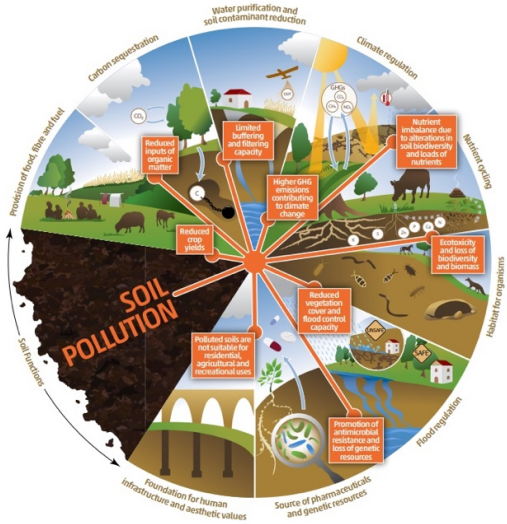
MASTER THESIS PROPOSAL

Title: interplay of diffusion and sedimentation for small particles: Towards understanding pollutant transfer in soils

Keywords: particles, sedimentation, diffusion, dynamic light scattering

Description: Understanding and predicting the transfer of pollutants in soil, such as metal particles all the way to the now infamous microplastics, is a pressing environmental question. Transcribed to a scientific question, we deal with the movement of nm-µm particles, of various densities, inside an opaque porous matrix filled with water. In the bulk, depending on the particle size and mass, a combination of diffusion (stochastic motion) and sedimentation (directional motion) takes place and this balance is neatly represented by the so-called gravitational Peclet number [1]. Under confinement (which entails also interactions with the matrix) the situation is of course much more complex.

To start from a simple case, in this M2 project we want to investigate the particle motion at different gravitational Peclet numbers using dynamic light scattering (DLS), both in a bulk liquid and inside a well-known porous matrix filled with a liquid (e.g. controlled porous glasses [2]). To begin with, the matrix will be optically matched by the confining liquid and will thus appear transparent [3]. DLS measures the particle motion via a time-correlation function, $g^2(t)$. For purely diffusive monodisperse particles, the diffusion coefficient can easily be extracted by fitting $g^2(t)$ with an exponential. However, its shape becomes complex when two types of motion are superimposed and/or in the presence of confinement. The goal is to measure and analyze these shapes, depending on which type of motion dominates.



FAO and UNEP 2021

Techniques: dynamic light scattering, determination of refractive indices (refractometer)
Applicant skills: experimental physicist/physical chemist with a particular interest in data analysis
Industrial partnership: No
Internship supervisor: natalie.malikova@sorbonne-universite.fr (Jussieu, 42-43, 2eme etage, 01 44 27 30 41)
Internship location: Laboratoire PHENIX (Jussieu campus)

Possibility of Doctoral thesis: YES This M2 project is a preparative study for a PhD position opening in autumn 2025 (funding already available), where X-ray scattering and imaging methods (at synchrotron facilities) will be used to probe particle motion in increasingly challenging matrices (model soils), which have the great disadvantage of being opaque [4]. This preliminary work will be essential, as the data from dynamic light scattering and the X-ray based methods is very similar.

[1] [Piazza14] Piazza, R. Settled and Unsettled Issues in Particle Settling. *Rep. Prog. Phys.* **2014**, *77* (5), 056602. [Berut19] A. Berut, O. Pouliquen, Y. Forterre, Brownian Granular Flows Down Heaps, *Phys. Rev. Lett.* **2019**, *123*, 2448005.
[2] [Enke03] D. Enke, F. Janowski, W. Schwieger, Porous glasses in the 21st century, *Micro. and Meso. Materials* **2003**, *60*, 19-30.
[3] [Beschieru09] V. Beschieru, B. Rathke, S. Will, Particle diffusion in porous media investigated by dynamic light scattering, *Micro. and Meso. Materials* **2009**, *125*, 63-69.
[4] ANR TRANSOIL, Transport of environmentally relevant particles in non-transparent soil-like porous structures, accepted July 2024, project starting April 2025.