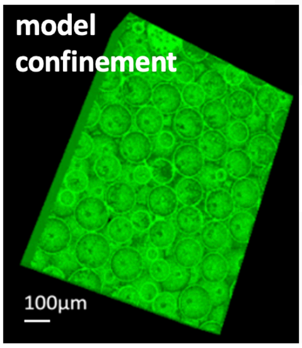
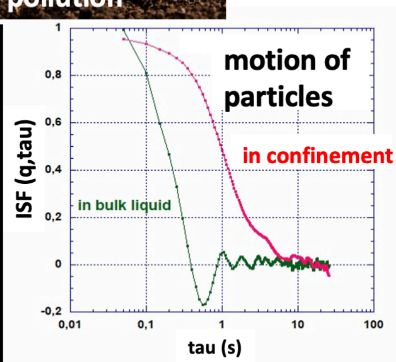
PHD POSITION

Interplay of diffusion and sedimentation of microparticles in confinement:

Towards understanding pollutant transport in soils

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 Péclet number [1]. Under confinement (and interactions with the matrix) the situation is naturally much more complex.





Currently the leading field for tracking particle dynamics in model solid porous media is based on optical microscopy techniques, which require optically transparent samples and track individual particles. The ultimate goal of this experimental PhD is however to measure the movement of microparticles inside a non-transparent porous matrix, resembling natural porous matrices such as soil. This remains a true challenge, however in PHENIX we have recently developed an X-ray based method that indeed allows such measurements [2]. Our way of tackling the problem is not via single particle tracking (as in optical microscopy mentioned above), but making use of time-correlations functions, such as the $g^2(t)$ function available from standard dynamic light scattering (DLS) experiments, reaching ultimately the intermediate scattering function (ISF) [3]. ISF is a very interesting quantity, which characterises the individual particular motion and, importantly, it can be measured for highly concentrated systems of particles, where individual trajectories cannot be disentangled and single particle tracking fails. There is a great interest, both in the experimental and simulation research communities, in understanding the different forms of the ISF and how diffusive (stochastic) motion and directional motion (such as sedimentation or active-particle propulsion) influence this quantity and thus how we can model and interpret it [4].

This PhD is part of a 4-year project (ANR TRANSOIL 2025-29, “Transport of environmentally relevant particles in non-transparent soil-like porous structures”), which will enable interaction with parallel theory and simulation activities, as well as with specialists in soil mineralogy and models of soil (IC2MP, Poitiers). This experimental PhD project has a rich range of potential activities, that can be tuned to the inclinations of the candidate. These include the choice and design of model confining matrices, selection of mobile particles in the interesting range of gravitational Péclet numbers, test measurements on transparent samples using a standard DLS set-up, building up towards the use of X-ray imaging and scattering based at synchrotron sources, exploration of the differential dynamic microscopy (DDM) methodology [3], which allows the analysis of a time-series of images (optical or X-ray) leading to ISF [3].

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[2] Levitz P.; Michot L.; Malikova, N.; Scheel, M. and Weitkamp, T. *submitted.*

[3] [Cerbino08] Cerbino R., Trappe V., Phys. Rev. Lett, **2008**, 100, 188102. [Cerbino17] R. Cerbino and P. Cicuta, J. Phys. Them. B **2017**, 147, 110901.

[4] [Kurzthaler16] Kurzthaler, C.; Leitmann, S.; Franosch, T. *Sci Rep* **2016**, *6* (1), 36702.

Keywords: confinement, porous media, microparticles, diffusion, sedimentation, light and X-ray scattering

Period: 3-year grant starting in October/November 2025. **Salary:** Gross salary 1768€/month.

Candidate Profile: experimental physicist or physical chemist with a good knowledge of scattering techniques and a particular interest in data analysis. Programming skills are an advantage.

Contact: Please send a CV and a motivation letter to Natalie MALIKOVA, **natalie.malikova@sorbonne-universite.fr, PHENIX laboratory, Tel: +33 144274031.**

PHENIX is a laboratory at the Sorbonne University is at the interface between Chemistry, Physics and Materials Science with a long-standing expertise of colloidal systems, electrolytes and fluids under confinement. Its strength lies in a combination of experimental and modelling activities (numerical simulations). Several international projects and networks are in place in PHENIX, providing a rich and multinational environment.