Master 2: *Physics of Complex Systems*

INTERNSHIP PROPOSAL

Laboratory name: **Laboratory of Condensed Matter Physics**
CNRS identification code: **UMR7643**
Internship director'surname: **Denis GREBENKOV**
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Internship location: **Laboratory of Condensed Matter Physics, Ecole Polytechnique, Palaiseau, France**
Thesis possibility after internship: YES
Funding: NO (but it is possible to apply for a scholarship from Ecole Polytechnique)

Theory and modeling of diffusion in heterogeneous media, with applications to single-particle tracking in living cells

The transport of macromolecules and organelles inside living cells is a complicated phenomenon with various regimes (sub-diffusive, super-diffusive, intermittent, transitory…) whose physical origins remain poorly understood. The new experimental techniques of single-particle tracking based on optical tweezers have been recently applied in microbiology in order to study cellular transport, as well as structural and functional properties of living cells. Since these techniques typically acquire few random trajectories (generated by unknown stochastic process), the problem of the best statistical analysis of acquired data and their most reliable biophysical interpretation becomes fundamental. In fact, one faces a very general question: How can one characterize a stochastic process from its single random trajectory?

The internship focuses on theoretical and numerical study of random trajectories in spatio-temporal heterogeneous media. The first stage consists in generating random trajectories from recently developed models of heterogeneous diffusion (with time-dependent or space-dependent diffusion coefficients). These trajectories mimic experimentally acquired data from single-particle tracking experiments. In the second stage, these trajectories will be analyzed by various statistical methods aiming at identifying spatial and temporal heterogeneities and at distinguishing different regimes of intracellular transport. This systematic study should help to identify the most efficient inference techniques, which can then be applied to experimentally acquired trajectories of tracers in living cells. The ultimate goal of this research is a better understanding of cellular transport and its biophysical origins.

The candidate is expected to have a solid background in statistical/theoretical physics and/or mathematical statistics, be skilled in numerical simulations (e.g., in Matlab), and motivated for interdisciplinary research. The internship can potentially be continued as a PhD thesis under the condition of finding a PhD scholarship (in order to be able to apply for such a scholarship at Ecole Polytechnique, the candidate should have excellent notes).

Bibliography

D. S. Grebenkov, *Probability Distribution of the Time-Averaged Mean-Square Displacement of a Gaussian Process*, Phys. Rev. E **84**, 031124 (2011).

E. Bertseva, D. S. Grebenkov, P. Schmidhauser, S. Gribkova, S. Jeney, L. Forro, *Optical Trapping Microrheology in Cultured Human Cells*, Eur. Phys. J. E **35**, 63 (2012).

Y. Lanoiselée and D. S. Grebenkov, *Unravelling intermittent features in single particle trajectories by a local convex hull method*, Phys. Rev. E 96, 022144 (2017)