Internship / Thesis

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Brownian Motion near Soft Interfaces

Motility of microscopic biological entities with the aim of reaching specific targets is a central question of biophysics, as evidenced by: cancer metastasis, durotaxis of stem cells, antibody recognition, or DNA replication, among numerous other examples. In an idealization attempt (and neglecting the additional charge effects for now, as well as any genetic input), this problem could perhaps be reduced to simple mechanics through a combination of four essential ingredients: viscous flow, elastic boundaries, confined environment, and thermal fluctuations. In echo to this point, a key problem of modern nanoscience amounts to understanding how to build the missing links between the antinomic molecular and continuum descriptions of matter or, stated differently, between the bottom-up and top-bottom approaches of condensed matter. Therefore, once again, combining continuum ingredients such as hydrodynamics and elasticity, together with molecular fluctuations at small scales, emerges as a crucial task. Right from the above arguments, the study of Brownian motion in soft-lubricated environments appears as one of the canonical problems of biophysics and nanophysics. Despite the obvious character of this statement, it is intriguing to notice that theoretical studies are scarce on the topic, and that experimental pieces of evidence are inexistant - to the best of our knowledge. The present project thus naturally aims at filling this gap, and further utilizing the associated knowledge production to design a novel strategy: harvesting the seemingly-useless environmental noise in order to perform specific tasks as various and important as particle trapping and transport, surface patterning, non-contact rheology, or biological filtering. Our strategy is to develop several simultaneous experiments, within an existing national consortium, and together with an international network of collaborators that are experts in the field of elastohydrodynamics. The various techniques might involve for instance: optical tweezers, atomic-force microscopy, microfluidics, physicochemical sample preparation… Besides, numerical and theoretical efforts will be dedicated to the resolution of the non-trivial governing system of equations: a 3D non-linear coupled Langevin problem including multiplicative noise and external potential. The student, interested by some of these aspects of our activities should not hesitate to visit our website and contact us for more details.