Master 2 Internship

Title: Thermodynamics of 2 anisotropic nano-particles levitating in vacuum : towards sympathic cooling the rotational degrees of freedom

Type: theoretical

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PhD funding (if any): not yet

Project:

In the past years, the underdamped dynamics of a *single* Brownian nanoparticle trapped in vacuum by light has sparked considerable interest. The study of the three-dimensional mechanical oscillator, formed by a nano-sphere in a non-harmonic optical potential, has helped to understand the influence of very weak non-conservative forces [1]. When the trapped object is not spherical, the torque transfer from the elliptically polarized laser beam to matter allows for imparting rotation at giant speeds of 10^{10} rad/s [2]. This transfer mechanism, first experimentally observed in 2018**, has been explained recently by our group [3], as well as the rotational dynamics at moderate vacuum pressure (~mbar).** Today, we are reaching a **complete understanding of the 6-dimensional dynamics of a trapped nano-dimer** (translation + rotation).

In this internship, we propose to study the coupling between two anisotropic particles. The Langevin dynamics will be solved for the translation and rotation motion simultaneously. Toy models and exact calculation will be used. We expect several dynamical regimes to appear, depending on the degree of synchronisation of the motion. For each regime, we will compute the exchange of work, angular momentum, and heat between the particles, seeking in particular a way to make sympathetic cooling between them.

References :

[1] Y. Amarouchene, M. Mangeat, B.V. Montes, L. Ondic, T. Guérin, D. S. Dean, Y. Louyer, « Nonequilibrium Dynamics Induced by Scattering Forces for Optically Trapped Nanoparticles in Strongly Inertial Regimes », Phys. Rev. Lett. 122, 183901 (2019)
https://doi.org/10.1103/PhysRevLett.122.183901

[2] R. Reimann, M. Doderer, E. Hebestreit, R. Diehl, M. Frimmer, D. Windey, F. Tebbenjohanns, and L. Novotny, « GHz Rotation of an Optically Trapped Nanoparticle in Vacuum », Phys. Rev. Lett. 121, 033602 (2018)
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.121.033602

[3] L. Bellando, M. Kleine, Y. Amarouchene, M. Perrin, and Y. Louyer. « Giant Diffusion of Nanomechanical Rotors in a Tilted Washboard Potential », Phys. Rev. Lett. 129, 023602 (2022).

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.129.023602