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PhD proposal

Engineering fast relaxation in microdevices and colloids

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Grant: 3 year contract by the CNRS, including base salary and complement for light teaching duties (ACE[1]) – Net salary ~1650€/month. Scientific project fully funded by the ANR[2].

Schedule: The PhD can start anytime between December 2018 and October 2019

Abstract:

This experimental project aims at studying time dependent protocols which help a system to relax from an initial state (possibly at equilibrium but not necessarily) to another one, faster than the natural relaxation time (see illustration figure. 1). While similar ideas emerged recently for isolated quantum systems, the goal is here to focus primarily (although not exclusively) on control of systems that are thermostated in some sense, in particular in the micromechanics and microelectronic realm.

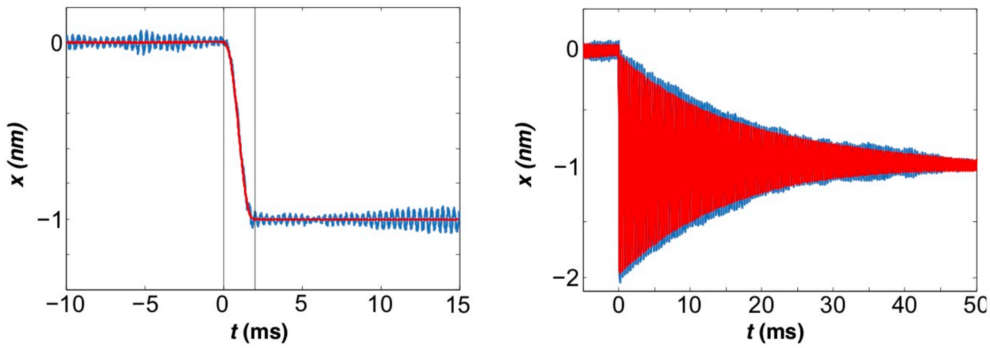

Figure 1 – *Example of an engineered step of a microscopic oscillator: applying a sudden force results in a 50 ms relaxation towards the new equilibrium position (right), whereas using a pre-computed force scheme, the same equilibrium can be reach in only 2 ms (left).*

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[1] ACE: Allocation Complémentaire d'Enseignement (64h teaching duty per year)
[2] ANR : Agence Nationale de la Recherche, major public funding agency for scientific projects in France.

Four main problems will be analyzed:

- Definition of protocols needed to speed up specific equilibration processes (this part will be done in collaboration with a team of theoreticians).
- Application of these protocols in experiments on the relaxation between equilibrium states of micro-oscillators and confined Brownian particles.
- Limiting factors for applications, robustness and energetics issues.
- Fast relaxation between non-equilibrium steady states.

These four problems present questions of particular current interest, not only from a fundamental perspective, but also for the large number of potential applications that they might have in statistical physics, in chemistry, in biology and in the design of small devices where the role of fluctuations cannot be neglected. A simple example is the fast transport of objects with optical traps. These kinds of systems in contact with one or several heat baths are important for they will illustrate the possibility of controlling complex systems with several degrees of freedom.

Within this context we have already performed three successful proof-of-principle experiments [1-3], and a theoretical article [4] which give credit to this proposal. One of them led to patentable protocols for scanning force microscopy which demonstrate a real potential follow-up for applications.

The interested candidate has to be motivated by the experimental work performed in close collaboration with theoreticians in statistical physics. The experiments will give the candidate an opportunity to discover and use optical traps, atomic force microscopes, electron microscopes, small scale lithography and low noise amplifiers and detectors.

References:

[1] I. A. Martinez, A. Petrosyan, D. Guéry-Odelin, E. Trizac and S. Ciliberto, Engineered swift equilibration of a Brownian particle, Nature Phys. 12, 843 (2016).

[2] A. Le Cunuder, I. A. Martínez, A. Petrosyan, D. Guéy-Odelin, E. Trizac, and S. Ciliberto, Fast equilibrium switch of a micro mechanical oscillator, Appl. Phys. Lett. 109, 113502 (2016).

[3] Marie Chupeau, Benjamin Besga, David Guéry-Odelin, Emmanuel Trizac, Artyom Petrosyan, and Sergio Ciliberto, Thermal bath engineering for swift equilibration, Phys. Rev. E 98, 010104(R) (2018).

[4] Marie Chupeau, Sergio Ciliberto, David Guéry-Odelin and Emmanuel Trizac, Engineered swift equilibration for Brownian objects: from underdamped to overdamped dynamics, New J. of Phys. 20 075003 (2018).