Optical control of Brownian nano-engines

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Optical traps have now become central experimental tools for measuring forces at the nanoscale with outstanding positional and force resolutions. Because of their small sizes, optically trapped objects have enabled thermally limited force with sensitivity with remarkable features that are currently exploited in a vast variety of contexts, ranging from biology [1] to optomechanics [2]. Recently, physicists have realized that optically trapped Brownian particles constitute ideal test systems for non-equilibrium physics with a great variety of stochastic protocols under external force fields that can be implemented [3, 4].

This project aims at conveying the methods and tools of optimal control in context of nanoscaled stochastic engines [5,6]. In the light of optimal control, we plan to study thermodynamic cycles induced on single nanospheres optically trapped in a fluid. By decomposing a cycle into successive sequences that can each be optimized with respect to their duration, expended work and/or dissipated heat, the project will study how optimization can affect and enhance the power output, the cycle time, and potentially the efficiency of a nanoscaled engine operating on optimized cycles.

Intertwining theory and experiment and grounded on recent promising results obtained by the IPCMS-ISIS collaboration, the project is structured in three objectives:

- Developing the theoretical and experimental tools necessary to implement optimized temperature-based protocols;
- Combining stiffness-based and temperature-based protocols for optimizing full thermodynamic cycles, including the possibility of adiabatic sequences;
- Designing new protocols that include the relevant figures-of-merit of a nano-engine (cycling time, power output, efficiency) as part of the optimization procedure.

Such optimized protocols will give the possibility to explore Brownian stochastic engines in uncharted energetics regimes. From a practical point of view, the possibility to extract "optimized" efficiencies at the level of such Brownian stochastic engines could open new strategies for the optimization of macroscopic heat machines.

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