Entropy production and fluctuation theorems for Langevin processes under continuous non-Markovian feedback control.

M.L. Rosinberg
Laboratoire de Physique Théorique de la Matière Condensée, CNRS and Université Pierre et Marie Curie, 4 place Jussieu, 75252 Paris Cedex 05, France

Entropy production in small stochastic systems under feedback control is an issue that has attracted much theoretical attention over the last few years, at the crossroad between statistical physics and information theory [1]. In this talk, I will present some recent work that focuses on systems in which measurements and actuation are performed continuously, i.e., repeated with a period shorter than the characteristic time scales of the dynamics - typically an underdamped Langevin dynamics. I will discuss the influence of a time delay between the input signal and the output control action, a situation that occurs in many biological or artificial systems (e.g. in the control of vision and posture, or in laser networks). The system then settles into a nonequilibrium steady state (NESS) where entropy is permanently produced. Since the feedback makes the dynamics non-Markovian, one must properly revisit the so-called “microscopic reversibility condition” which is at the heart of the fluctuation relations and which relates the heat exchanged with the thermal bath along a single trajectory to the probabilities of observing the trajectory and its time-reversal [2]. In particular, I will show that non-Markovianity leads to a “Jacobian effect” [3] that went unnoticed in previous theoretical studies that mainly focused on discrete feedback protocols in which the controller acts at predefined time intervals.

I will also discuss the influence of measurement errors (i.e. detector noise), taking as an example a cold damping setup in which a harmonic oscillator (e.g. the cantilever of an AFM or the mirror of an interferometric detector) in contact with a heat bath is submitted to a velocity-dependent feedback force that reduces the random motion [4].