Fluctuations in out of equilibrium systems

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Résumé

The study of the fluctuations in out of equilibrium systems is a subject of current interest ranging from the dynamical systems to the stochastic ones. There are only a few theoretical results which may predict several statistical properties of these fluctuations. This is the case of the Gallavotti-Cohen fluctuation theorem(FT) which has been first found in the context of dynamical systems and later extended to stochastic ones. The proof relies upon several hypothesis which merit to be tested experimentally. During this talk we will first recall the general properties of FT. We will briefly discuss the problems of testing them in dynamical systems. The rest of the talk will be focused on stochastic systems dominated by thermal fluctuations. While fluctuations always play a negligible role in large systems, their influence may become extremely important in small systems (nano and micro devices, biological systems etc.) driven out of equilibrium. We will discuss two simple and pedagogical cases : i) the power fluctuations in an electrical dipole driven out of equilibrium by a small constant current ; ii) the work fluctuations of an oscillator in contact with a heat reservoir and driven out of equilibrium by an external force. We show that FT are experimentally accessible and valid. Furthermore, we stress that FT can be used to measure the dissipated power in the system by just studying the PDFs symmetries. The harmonic oscillator driven out of equilibrium will be used to discuss the role of the Jarzynski equality and the Crooks relation, which are somehow related to FT. We find that, independently of the time scale and amplitude of the driving force, both relations are satisfied. These results give credit, at least in the case of Gaussian fluctuations, to the use of these relations in biological and chemical systems to estimate the free energy difference ΔF between two equilibrium states. An alternative method to estimate ΔF in isothermal process is proposed too.