

Nordic Workshop on Statistical Physics: Biological, Complex and Non-equilibrium Systems

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ALBANOVA COLLOQUIUM - Stochastic Thermodynamics: Theory and Experiments

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Stochastic thermodynamics provides a framework for describing small systems embedded in a heat bath and externally driven to non-equilibrium. Examples are colloidal particles in time-dependent optical traps, single biomolecules manipulated by optical tweezers or AFM tips, and motor proteins driven by ATP excess. A first-law like energy balance allows to identify applied work and dissipated heat on the level of a single stochastic trajectory. Total entropy production includes not only this heat but also changes in entropy associated with the state of the small system. Within such a framework, exact results like an integral fluctuation theorem for total entropy production valid for any initial state, any time-dependent driving and any length of trajectories can be proven [1]. These theoretical predictions have been illustrated and tested with experiments on a colloidal particle pushed by a periodically modulated laser towards a surface [2]. Key elements of this framework like a stochastic entropy can also be applied to athermal systems as experiments on an optically driven defect center in diamond show [3,4]. For mechanically driven non-equilibrium steady states, the violation of the fluctuation-dissipation theorem can be quantified as an additive term directly related to broken detailed balance (rather than a multiplicative effective temperature) [5,6]. Integrated over time, a generalized Einstein relation appears which we have recently verified experimentally [7]. Finally, optimal protocols are derived which (i) minimize the work required to switch from one equilibrium state to another in finite time [8] and (ii) maximize the power of stochastic heat engines operating between two heat baths [9].

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