FLUCTUATION RELATIONS FOR THE DISSIPATION

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EXTENDED ABSTRACT

The fluctuation theorems characterize the probability distribution of values of the dissipation in nonequilibrium systems and prove that the average dissipation will be positive. Transient Fluctuation relations are the best understood. They are known to be exact for systems of arbitrary size, arbitrarily near or far from equilibrium.[1] Previously very few exact results were known in nonequilibrium statistical mechanics. Their application to small systems coincided with an upsurge of interest in nanotechnology and nanobiology and the study of small bio-engines. The applicability of the transient fluctuation relations far from equilibrium also mean that they are an important for large deviation theory.

Here we will discuss variants of the fluctuation theorem that can be derived from the transient fluctuation theorem, and which are valid in various limits, or subject to particular conditions. We will focus on fluctuation theorems for steady states [2], in local regions within a larger system [3] and in systems subject to external noise [4].

The subject of the transient fluctuation theorems is the dissipation function, which is related to the entropy production from linear irreversible thermodynamics. We will show that in order for steady state fluctuation relations for the dissipation function to hold, time reversibility, ergodic consistency and a recently introduced form of correlation decay, called T-mixing, are sufficient conditions. Our results are not restricted to a particular model and show that the steady state fluctuation relation for the dissipation function holds near or far from equilibrium subject to these conditions. [2]

We will also consider how a fluctuation theorem can be obtained for a small open subsystem within the large system. If a fluctuation theorem for the dissipation in a subsystem is considered, we find that a correction term has to be added to the large system fluctuation theorem due to correlation of the subsystem with the surroundings. Its analytic expression can be derived provided some general assumptions are fulfilled, and its relevance has been checked using numerical simulations. [3]

Another system of interest is the systems that are subject to external noise. We provide a derivation of this fluctuation theorem for systems driven by both deterministic and stochastic forces. It turns out that it is still valid, provided the dissipation is carefully defined. The total dissipation is explicitly the sum of two dimensionless works for which fluctuation relations may fail. We numerically study their range of validity of fluctuation relations for the total dissipation, the contribution from the deterministic driving force and the stochastic force, and point out in which limit a noise can be neglected. [4]

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