Work probability distribution in manipulated mean-field systems

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Recent improvements in micromanipulation techniques have made it possible to measure probability distributions of the work exerted on systems subject to external manipulation. In particular, the probability distribution of the work has been measured in RNA pulling experiments [1] and for micron-sized colloidal particles dragged through a fluid [2]. The importance of the knowledge of work distributions in such experiments resides in the fact that one can evaluate the free energy difference between the final and the initial state of the system by exploiting the Jarzynski equality [3]

$$\left\langle \mathrm{e}^{-\beta W} \right\rangle = \mathrm{e}^{-\beta \Delta F}. \tag{1}$$

Using a path integral formalism, we derive an expression for the work probability distribution for a system characterized by a generic mean-field free energy $F_\mu(M)$, where μ is the parameter which is manipulated according to a given protocol $\mu(t)$. We discuss the relevance of our approach by comparing the calculated work distributions with those obtained by simulating the manipulation process, exhibiting the limitations of eq. (1) in the experimental determinations of free energy difference.

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