A simple quantum derivation of the Jarzynski and Crooks equalities

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We [1] obtain the Crooks and the Jarzynski non-equilibrium fluctuation relations using a direct quantum-mechanical approach for a finite system that is either isolated or coupled not too strongly to a heat bath. These results were hitherto derived mostly [2,3] in the classical limit. The two main ingredients in the picture are the time-reversal symmetry and the application of the first law to the case where an "agent" performs work on the system. No further assumptions regarding stochastic or Markovian behavior are necessary, neither a master equation or a classical phase-space picture are required. The simplicity and the generality of these non-equilibrium relations are demonstrated, giving very simple insights into the Physics.

[1] D. Cohen and Y. Imry, Phys. Rev. E 86, 011111 (2012).

[2] see, however, e.g. J. Kurchan, arXiv:cond-mat/0007360; P. Talkner and P. Hanggi, J. Phys. A 40, F569 (2007).

[3] C. Jarzynski and D. K. Wojcik, Phys. Rev. Lett. 92, 230602 (2004).