

Shortcuts of freely relaxing systems using equilibrium physical observables

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Abstract-

Many systems, when initially placed far from equilibrium, exhibit surprising behavior in their attempt to equilibrate. Striking examples are the Mpemba effect and the cooling-heating asymmetry. These anomalous behaviors can be exploited to shorten the time needed to cool down (or heat up) a system. Though, a strategy to design these effects in mesoscopic systems is missing. We bring forward a description that allows us to formulate such strategies, and, along the way, makes natural these paradoxical behaviors. In particular, we study the evolution of macroscopic physical observables of systems freely relaxing under the influence of one or two instantaneous thermal quenches. The two crucial ingredients in our approach are timescale separation and a nonmonotonic temperature evolution of an important state function. We argue that both are generic features near a first-order transition. Our theory is exemplified with the one-dimensional Ising model in a magnetic field using analytic results and numerical experiments.

Index Terms- Nonequilibrium statistical mechanics; Stochastic thermodynamics; Memory effects; Anomalous relaxation

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