The Correlational Entropy Production in a Finite Bath with a Negative Temperature

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A closed many-body system undergoes the unitary evolution, and the entropy of the full system always keeps unchanged, but a small partition of the whole system exhibits a local relaxation. We study the local relaxation behavior of a many-body system, which is composed of N two-level systems (TLSs) exchanging energy with each other. One of the TLSs is treated as the open system, while all the others are regarded as its environment, and we consider the initial states of the bath degrees have inverse populations, namely, they start from a negative temperature, which is beyond the standard thermodynamics. In this case, we find that the total correlation entropy, which sums up the entropy of all the N TLSs, approximately exhibit a monotonic increase; in contrast, the entropy of each single TLS increases and decreases from time to time, and the entropy of the whole many-body system keeps constant during the unitary evolution. Moreover, for usual cases that an open system is weakly coupled with a canonical bath, this total correlation entropy increase could well return to the irreversible entropy production in the standard thermodynamics. Therefore, the correlational entropy production provides a potential candidate to generalize the standard second law to non-canonical situations.

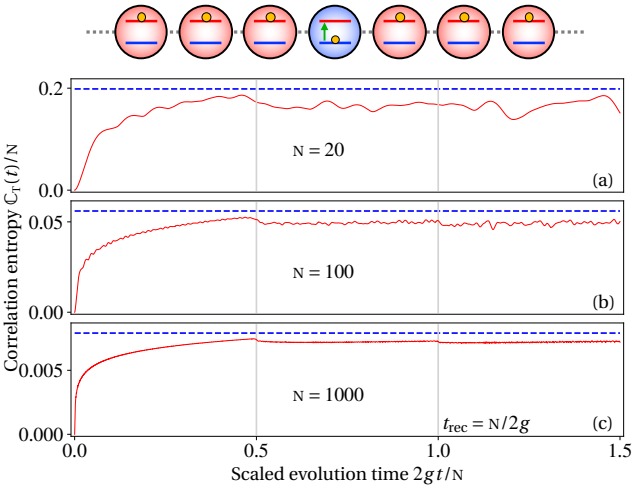

Figure 1: Evolution of the total correlation entropy for the TLS chain with different sizes

References

[1] S-W Li and C P Sun, Phys. Rev. A **103**, 04221 (2021)