Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Temperature of a small quantum system as an internal property

JIAOZI WANG, WENGE WANG, Univ of Sci Tech of China — Equilibration of small quantum systems is a topic of current interest both theoretically and experimentally. In this work, we study the extent to which a temperature can be assigned to a small quantum (chaotic) system as an internal property, but not as a property of any large environment. Specifically, we study a total system, which is composed of an Ising chain in a nonhomogeneous transverse field and an additional spin coupled to one of the spins in the chain. The additional spin can be used as a probe to detect local temperature of the chain. The total system lies in a pure state under unitary evolution and initial state of the chain is prepared in a typical state within an energy shell. Our numerical simulations show that the reduced density matrix of the probe spin approaches canonical states with similar temperatures at different locations of the chain beyond a relaxation time, and the results are close to the theoretical prediction given by the statistical mechanics in the thermodynamic limit, namely $\beta = \frac{\partial \ln \rho(E)}{\partial E}$ with $\rho(E)$ being the density of states. We also study effects due to finite size of the chain, including the dependence on initial state of the probe and difference of numerically-obtain temperature from theoretical results.

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Date submitted: 04 Nov 2015

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