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Equilibration of holographic random tensor networks

Recent years have enjoyed substantial progress in capturing properties of complex quantum systems by means of random tensor networks (RTNs). Such tensor networks, formed by locally contracting random tensors chosen from the unitary Haar measure, define ensembles of quantum states whose properties depend only on the tensor network geometry and bond dimensions. Of particular interest are random tensor networks on hyperbolic
geometries, resembling those of critical boundary states of holographic bulk-boundary dualities. In this work, we elevate static pictures of ensemble averages to a dynamic one, to show that RTN states exhibit equilibration of time-averaged operator expectation values under a highly generic class of Hamiltonians with non-degenerate spectra. We prove that RTN states generally equilibrate at large bond dimension, and that three classes of RTN geometries –tensor trains, regular hyperbolic tilings, and single "black hole"tensors –equilibrate in the scaling limit. Furthermore, we prove a hierarchy of equilibration between finite-dimensional instances of these three classes, suggesting an equivalent hierarchy between corresponding many-body phases and reproducing a holo-
graphic degree-of-freedom counting for the effective dimension of each system. These results demonstrate that
RTN techniques can probe aspects of late-time dynamics of a wide range of quantum many-body phases.

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