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Symmetry-resolved entanglement entropy in random tensor networks

In quantum systems with global symmetries, entanglement exhibits a refined structure across symmetry sectors, captured by the symmetry-resolved entanglement (SRE) entropy. In $U(1)$-symmetric free field theories, SRE entropies typically exhibit equipartition, remaining independent of the charge sector. In this work, we demonstrate the breakdown of equipartition in a random tensor network state with $U(1)$ symmetry. By introducing novel charge constraints on the random tensors, we engineer an emergent $U(1)$ gauge field and derive its effective action on the curved space defined by the network. We uncover a holographic interpretation in which the SRE entropies receive contributions from the saddle-point configuration of the emergent gauge field on the minimal surface anchored to the boundary of the subsystem. The gauge field dynamics subjected to the charged boundary condition are directly responsible for the breakdown of equipartition.

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