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Robustness of Magic in the quantum Ising chain via Quantum Monte Carlo tomography

We study the behavior of magic as a bipartite correlation in the quantum Ising chain across its quantum phase transition, and at finite temperature. In order to quantify the magic of partitions rigorously, we formulate a hybrid scheme that combines stochastic sampling of reduced density matrices via quantum Monte Carlo, with state-of-the-art estimators for the robustness of magic - a *bona fide* measure of magic for mixed states. This allows us to compute the mutual robustness of magic for partitions up to 8 sites, embedded into a much larger system. We show how mutual robustness is directly related to critical behaviors: at the critical point, it displays a power law decay as a function of the distance between partitions, whose exponent is related to the partition size. Once finite temperature is included, mutual magic retains its low temperature value up to an effective critical temperature, whose dependence on size is also algebraic. This suggests that magic, differently from entanglement, does not necessarily undergo a sudden death.

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