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Quantum Magic via Perfect Sampling of Matrix Product States

We introduce a novel breakthrough approach to evaluate the nonstabilizerness of an N-qubits Matrix Product State (MPS) with bond dimension χ. In particular, we consider the recently introduced Stabilizer Rényi Entropies (SREs). We show that the exponentially hard evaluation of the SREs can be achieved by means of a simple perfect sampling of the many-body wave function over the Pauli string configurations. The MPS representation enables such a sampling in an efficient way with a computational cost $O(N\chi^3)$, no matter the Rényi index $n > 0$. The accuracy, being size-independent, can be arbitrarily improved with the number of samples. We benchmark our method over randomly generated magic states, as well as in the ground-state of the quantum Ising chain. Exploiting the extremely favourable scaling, we easily have access to the non-equilibrium dynamics of the SREs after a quantum quench.

Abstract category

Numerical Methods

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