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Tree Tensor Networks for quantum many-body systems at finite temperature

We develop and implement an efficient Tree Tensor Network based algorithm for computing the finite temperature many-body density matrix. This approach is particularly important because, since physical systems can never be cooled down to absolute zero temperature, a complete description of the physics behind the quantum computing devices has to account for finite temperature effects. However, the finite temperature, i.e. mixed state scenario, represents an additional challenge in comparison to the already computationally demanding zero-temperature quantum many-body simulations. For low-dimensional lattice systems, various applications have demonstrated that tensor network methods are a powerful numerical tool, extending possible simulations to a large number of particles. We present the numerical techniques for computing the purity, Von Neumann entropy, Rényi entropies of any order, negativity, and entanglement of formation for the mixed state systems. Our approach is successfully applied to one-dimensional quantum Ising model, and moreover, to the systems of neutral Rydberg atoms trapped in the optical tweezer arrays, representing a physical quantum computing and simulation platform.

Abstract category

Numerical Methods

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