New Approaches to Get the Property of Quantum Spin Systems in the Thermodynamic Limit

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To reveal the bulk property of the uniform one-dimensional (1D) system, we discuss two approaches; one is the hyperbolic deformation for the finite system [1, 2, 3], the other is the infinite uniform matrix product state (IUMPS) for the infinite system.

The subtraction of the finite-size effect is important to estimate the bulk property from the finite lattice. The hyperbolic deformation suppresses the boundary effects efficiently, [1] and makes it possible to estimate the excitation gap of the $S = 1$ Heisenberg chain with high accuracy by using the finite-size data from the density matrix renormalization group (DMRG) method. [2] In recent our research, a scaling relation between energy correction to the excitation gap and deformation parameter is proposed in the deformed quantum spin systems, and this scaling is useful for the extraction of the bulk excitation gap in the undeformed limit. [3]

We can consider an infinite size wavefunction represented by the IUMPS directly, where the boundary effect no longer exists. The infinite time-evolving block decimation (iTEBD) algorithm [4] is well known as a way to update an IUMPS. The unit cell of the iTEBD must be at least two sites due to the imaginary time evolution via the Suzuki-Trotter decomposition. We pay attention to the periodicity of the IUMPS, because the periodicity is closely related to the translation symmetry of the state, for example, the magnetic plateau state. In this work, therefore, the modified Powell method is applied to the update of an IUMPS to treat also a unit cell containing one site. We investigate a transfer matrix from the IUMPS in the magnetic plateau states for $S = 1/2$ spin ladders, and find the degeneracy of dominant eigen values of the transfer matrix changes in response to the translational symmetry of the plateau state.

References

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