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Multi-impurity method for bond-weighted tensor renormalization group

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Tensor network (TN) methods are attracting much attention as powerful tools for computing strongly correlated many-body problems. The partition function of classical statistical systems can be represented by the TN form. However, the contraction of a large TN still requires an exponentially large computational effort. The concept of the real-space renormalization group resolves this problem. The tensor renormalization group (TRG) method and its variants calculate a coarse-grained tensor by information compression by the singular value decomposition. These methods can calculate the partition function approximately in the polynomial time. Recently, Adachi, et al. have proposed the bond-weighted TRG (BWTRG) method, which improves the accuracy of TRG by introducing a bond weight and distributing it appropriately.

In this presentation, we propose an algorithm to calculate higher-order moments of physical quantities based on BWTRG. We introduce a coarse-grained matrix on a bond representing a summation of all configurations of multiple impurities and derive its update rule. Our method is compared with conventional methods on the two-dimensional classical spin model. The proposed method achieves higher accuracy at a lower computational cost than the higher-order TRG algorithm. We also show that the finite-size scaling analysis of the squared magnetization provides critical exponents and distinguishes the weakly first-order and continuous phase transitions.

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