Contribution ID: **65** Type: **not specified**

Extracting conformal data from frustrated classical spin models with nuclear norm regularization techniques on tensor network renormalization algorithm

Wednesday, 27 March 2024 18:24 (3 minutes)

We propose a loop optimization algorithm based on nuclear norm regularization for tensor network. The key ingredient of this scheme is to introduce a rank penalty term proposed in the context of data processing. Compared to standard variational periodic matrix product states method, this algorithm can circumvent the local minima related to short-ranged correlation in a simpler fashion. We demonstrate its performance when used as a part of the tensor network renormalization algorithms [S. Yang, Z.-C. Gu, and X.-G. Wen, Phys. Rev. Lett. 118, 110504 (2017)] for the critical 2D Ising model. The scale invariance of the renormalized tensors is attained with higher accuracy while the higher parts of the scaling dimension spectrum are obtained in a more stable fashion.

Using the nuclear norm regularization techniques on tensor network renormalization algorithm, we study the phase diagram, the critical behavior, and the duality property of the antiferromagnetic 6-state clock model on the Union Jack lattice. We find that this model undergoes multiple phase transitions; there is the Berezinskii-Kosterlitz-Thouless, Z_6 symmetry breaking, and chiral transition
with decreasing temperature. Furthermore, we provide convincing numerical evidence that its quasi-long range order is well explained by the compactified boson conformal field theory (CFT) and the chiral transition is in perfect agreement with the Ising CFT, including central charge, scaling dimension spectrum, and operator product expansion coefficients.

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Session Classification: Poster

Track Classification: Poster presentation