Contribution ID: **29** Type: **not specified**

Real-space renormalization group analysis of the frustrated Ising ladder in a transverse field

Sunday, January 27, 2019 12:30 PM (25 minutes)

Studying phase transitions of the transverse-field Ising model is significant from the viewpoint of quantum annealing. Presence of a first-order phase transition is one of the most serious problems because it makes computation time of quantum annealing exponentially large as a function of the system size. We consider the frustrated Ising ladder in a transverse field, which is known to exhibit a first-order phase transition by means of numerical diagonalization. In this presentation, we study the phase transition of this model using the real-space renormalization group (RG) method to understand this transition more deeply. We propose an RG procedure in which a variational method is used after block partition of the ladder to find a low-energy space. Calculating the solution to the RG equation, we find a critical point not far from the value obtained by the numerical diagonalization. In addition, we show that the scaling exponent of the longitudinal field on the bottom row of the ladder is equal to one, the dimension of the system. This indicates that the phase transition is of first order. As a future work, it may be possible to study the system with transverse interactions or inhomogeneous transverse field in order to investigate whether the first-order phase transition can be avoided.

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Session Classification: Quantum Enhanced Optimization II

Track Classification: Quantum enhanced optimization