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Quantum decoration transformation for spin models

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The classical version of decoration transformation has been used to map lattice spin models into another equivalent lattice spin models. This transformation is a very useful tool for identifying a class of lattice spin models, since, it is possible to show a class of lattice spin models that can be map into another class of exactly solvable models. Here we present a quantum version of decoration transformation and show how this transformation could be applied to Heisenberg type models. This transformation can be useful to study the equivalence between two quantum spin systems such as a small cluster of quantum spin models or even lattice quantum spin models. The quantum decoration transformation by itself is an exact transformation, although the proposed transformation cannot be used to map exactly a quantum spin lattice model onto another quantum spin lattice model, since, the operators are non-commuting. However, it is possible mapping in the classical limit, establishing the equivalence between two quantum lattice spin models. To study the validity of this approach for quantum spin lattice model, we use the Zassenhaus formula, and we verify how the correction could influence the decoration transformation. The correction term involves the second-nearest-neighbor coupling, as well as the next nearest neighbors, which leads into a cumbersome task to establish the equivalence between both lattice models. This correction also gives us valuable information about its contribution, for most of the Heisenberg type models, this correction could be irrelevant at least up to the third order term of Zassenhaus formula. This transformation is applied to a finite size Heisenberg chain, so we compare with exact numerical results, and our result is consistent when the xy-anisotropy coupling is weak, we also apply to bond-alternating Ising-Heisenberg chain model, obtaining an approximate result.

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