Landau forbidden continuous quantum phase transition between two topologically valence bond solid states

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The Haldane gap phase of a quantum Heisenberg antiferromagnetic spin-1 chain can be regarded as an example of a topological order phase in one dimension, where nonlocal string order parameters were proposed to describe the dilute antiferromagnetic order in the ground state. Moreover, a unitary nonlocal transformation was also established to convert the nonlocal string order parameters to the local ones and reveal the hidden discrete Z2xZ2 symmetry. Recently, we have successfully generalized such a description scheme for the topological ordered ground states of higher integer spin chains with SO(2S+1) symmetry. Then for a one-dimensional quantum Heisenberg spin-2 chain, there exist two topologically distinct valence bond solid states in two different solvable limits. In order to construct the ground state phase diagram, we apply the infinite time evolving block decimation algorithms to the model Hamiltonian. Surprisingly, a continuous quantum phase transition appears between these two valence bond solid states, and is forbidden by the conventional Landau phase transition theory. From the scaling relation between the entanglement entropy and correlation length, we give rise to the quantum critical properties around this critical point.

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