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Application of the discrete WKB method to the ferromagnetic p-spin model with antiferromagnetic transverse interactions

We study the fully connected mean-field model with p-body ferromagnetic interactions and a transverse field. This model with p>2 has a quantum phase transition of first order as a function of the strength of the transverse field at T=0 [1]. This first-order transition is known to be reduced to second order by an introduction of antiferromagnetic transverse interactions [2], which makes the Hamiltonian non-stoquastic [3]. Thus the computational complexity is drastically reduced from exponential to polynomial. In order to understand this phenomenon in more detail, we applied the discrete WKB method [4] to analytically derive the coefficient of the exponential decay of the energy gap, b in exp(-bN), at the first-order transition. The result shows that the coefficient b is almost constant along the line of first order transition between the paramagnetic and ferromagnetic phases but changes significantly along the line of first order transitions within the ferromagnetic phase.

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