Thermodynamics, geometrical frustration and quantum fluctuations in coupled spin chains

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The linear-perturbation real space renormalization transformation (LPRG) is presented and applied to study quantum spin chains coupled by interchain interaction (k_1) weaker than intrachain one (k). The method is examined in two exact solvable cases: Ising chains on the square and triangular lattices and quantum XY chain. For the Ising model, in the second order in the cumulant epansion, the deviation of the critical temperature from the exact value is less than 1% for $0.5k > k1 > 0.15k$, but even in the case of the standard Ising model ($k_1 = k$) we found the value of T_c which differs by 2% from the exact one. For the quantum XY chain the deviation of the free energy value found by using LPRG from the exact Katsura result is less than 1% for $T/J > 1$, and for rather low temperature $T/J = 0.08$ is about 6%. The LPRG is used to study effects of interchain frustration on the phase transition in 2D Heisenberg spin chains with easy axis along the z direction. It is shown that contrary to the pure Ising model in systems with inplane interactions (XY), the interchain frustration does not destroy the finite-temperature transition. However, such a frustration changes the character of the phase transition from Ising-like to, probably, Kosterlitz-Thouless-like. We have also applied the LPRG method to calculate the isothermal magnetocaloric coefficient (M_T) for several spin models in disordered phases. Is is demonstrated that in the presence of antiferromagnetic fluctuations, M_T changes sign at some value of the magnetic field. Generally, M_T is negative if magnetic field competes with a short-range order, and consequently it can be an indicator of the change in the short-range correlation.