Ground-state and finite-temperature phase diagrams of the decorated Ising triangular lattice in a longitudinal magnetic field

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The mixed spin-(1/2, s) Ising model on a decorated triangular lattice with decorating spins placed into the longitudinal magnetic field is rigorously solved by means of the generalized decoration-iteration mapping transformation [1]. This technique allows one to find a precise analytical mapping relationship between the partition function of the considered mixed-spin model and the partition function of the spin-1/2 Ising model on a simple isotropic triangular lattice, which is well known [2,3]. By assuming the effect of the uniaxial single-ion anisotropy acting on decorating spins, we construct the ground-state phase diagrams for two representative values of decorating spins $s = 1$ and $s = 3/2$. It is demonstrated that the mutual interplay between the applied magnetic field and uniaxial single-ion anisotropy leads to relatively rich zero-temperature phase diagrams involving several long-range ordered ground states as well as intriguing paramagnetic phases for both mixed-spin systems. In latter phases, the investigated planar models are broken into sets of $3N$ spin atoms taking the same spin states due to a frustration of nodal spins. As a result, the non-zero residual entropy $S = Nk_B \ln 2$ can be detected in the paramagnetic phases.

The critical temperature of the decorated Ising triangular lattice as a function of the longitudinal magnetic field and uniaxial single-ion anisotropy parameter is also particularly examined for both the investigated values of decorating spins $s = 1$ and $s = 3/2$. In general, the critical temperature terminates the existence of the long-range order in the two-dimensional system at finite temperatures. As expected, the critical temperature corresponding to both the investigated mixed-spin planar models always vanishes at those zero-temperature phase transitions, where the long-range ordered ground state coexist with the paramagnetic one. Moreover, an interesting reentrant phenomenon can also be detected at finite temperatures when the uniaxial single-ion anisotropy is zero or negligibly weak and the intensity of the longitudinal magnetic field is comparable to the intensity of the exchange interactions between the nearest-neighboring spins due to a relatively high coordination number of the lattice. The observed phenomenon is more pronounced for the spin case $s = 3/2$ in comparison with the spin case $s = 1$.

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