Ground-state phase diagram of a diluted FCC magnet with modified RKKY interaction in an external magnetic field

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The ground-state phase diagram is studied for a model RKKY magnet with diluted FCC structure in an external magnetic field. The indirect RKKY interaction, modified by the exponential damping corresponding to the free-carriers localization, and a direct nearest-neighbours (NN) antiferromagnetic interaction are simultaneously taken into account. A concentration of the impurity spins, free-carriers density, NN interaction strength, mean-free path length and the external magnetic field are the variable parameters of the theory. Such a model can be useful for the description of dilute magnetic semiconductors, such as $Ga_{1-x}Mn_xAs$ [1-3].

The ground-state energy calculations are based on the exact expression resulting from the Ising-like hamiltonian. The numerical calculations are performed by the summation of exchange interactions over lattice sites with a relatively high accuracy, for the spin-spin interactions extending up to 100 lattice constants. Some material constants, typical for $Ga_{1-x}Mn_xAs$, have been assumed. A variety of the ground-state phases is shown in the figures, including the existence of diluted ferromagnetic and three antiferromagnetic phases (1^{st} kind, improved 1^{st} kind and 2^{nd} kind orderings). A possibility of occurrence of these distinct antiferromagnetic phases has already been predicted theoretically for such systems [4], although the external magnetic field has not been considered yet. On the other hand, the MC simulations, carried out recently by other authors [3], merely confirmed the existence of ferromagnetic phase in a restricted range of concentrations.

The effect of the external field on the phase diagrams, showing the field-induced changes in the stability regions of the discussed phases, is the main goal of the paper. For this purpose, the Zeeman-like term in the RKKY hamiltonian with the effective gyromagnetic factor is taken into account, following the theory presented in [5]. As it was shown in [5], the effective gyromagnetic factor depends on the free-carriers concentration and the RKKY contact potential. With such an amendment, the influence of the free-carriers concentration (*i.e.*, holes in the case of $Ga_{1-x}Mn_xAs$) on the ground-state phase diagram in the external magnetic field is examined. It has also been demonstrated that the damping of the RKKY interaction, as well as the NN direct antiferromagnetic couplings, play an essential role in the model.

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