Monte Carlo Simulation of Amorphous Magnets with Random Exchange Interactions

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Amorphous alloys based on rare-earth metals are of great interest due to their unique magnetic properties. In this work we report on the Monte Carlo simulation of magnetic properties of binary amorphous alloys of rare-earth metals with nonmagnetic 5d-transition metal (rhenium) which are not studied so far.

Using the Monte Carlo method within the frame of the Heisenberg model, the computer simulation of magnetic properties of pure amorphous Gd and Re-Gd amorphous alloys was performed. The model Hamiltonian contained two terms responsible for ferromagnetic exchange interaction J_1 between the nearest-neighbour Gd ions and for antiferromagnetic exchange interaction J_2 between the Gd ions in the second coordination sphere.

For pure amorphous Gd the dependence of the spin-glass transition temperature T_f on the J_1/J_2 ratio was calculated. Thus, the magnetic phase diagram for an amorphous magnet with competition of exchange interactions of different signs in the $J_1/J_2 - T$ coordinates was constructed.

In the models of the Re-Gd amorphous alloys, the spin-glass-like phase transition was also observed. With increasing concentration of Tb atoms, the transition temperature linearly increases, which is in a good agreement with the experimental results. The spin-glass transition is observed only above the percolation threshold in this system, i.e. at x>7 at. % Gd.

The temperature dependencies of spontaneous magnetization, Edwards–Anderson order parameter and magnetic susceptibility were calculated. The magnetic phase diagrams for the Re-Gd amorphous alloys were constructed which were in a good agreement with the experimental results. The magnetization curves, hysteresis loops, remanent magnetization, coercive field, spin-spin correlation functions at different temperatures are also calculated.

The magnetization relaxation after switching off the external magnetic field was studied. Our results qualitatively agree with the experimental results obtained for amorphous alloys based on rare-earth metals.

Magnetic structure of the Re-Gd amorphous alloys was studied on the microscopic level with the use of spin-spin correlation functions and angle spin correlation functions.