Non-equilibrium Critical Behavior of the 3D Classical Heisenberg Model

E.A. Pospelov, V.V. Prudnikov, P.V. Prudnikov, A.S. Lyakh

Dostoevsky Omsk State University, Omsk, Russia

Three-dimensional classical ferromagnetic Heisenberg spin systems are traditional models for the study of critical phenomena. One of the features arisen in describing the critical behavior is the critical slowing down effect. It is associated with an anomalous increase of relaxation time t_{rel} in the system close to critical temperature T_c. As a result, a statistical system at the critical point cannot achieve the equilibrium state during the whole relaxation process. The non-equilibrium evolution in this case displays some of the peculiarities, such as aging phenomena and the memory about the initial states, as well as violation of the fluctuation-dissipation theorem (FDT) [1-3].

We present results of Monte Carlo description of features of non-equilibrium critical behavior in three-dimensional classical Heisenberg model with evolution from different initial states. Usually, we can distinguish the high-temperature initial states created at temperatures $T_0 > T_{\mathrm{c}}$ and characterized by the initial magnetization $m_0 = 0$ and low-temperature initial states with $T_0 < T_{\mathrm{c}}$ and $m_0 \neq 0$. Initial states with magnetization $m_0 \neq 0$ give rise to a new time scale $t_m \sim m_0^{-k}$ with the exponent $k > 0$. This time scale produces a pronounced effect on the temporal behavior of magnetization, autocorrelation function, and response function [1, 4]

Study of influence of different initial states with $0 < m_0 \leq 1$ on relaxational properties of model have been carried out. It was established realization of scaling relation for time dependence of magnetization in form $M(t,t_m) = t^{-\beta/(\nu z)} F_m(t/t_m)$, where $F_{\mathrm{m}}(x)$ is the scaling function for magnetization, which has the form $F_m(x) \sim x^{1/k} \sim x^{(\theta'+\beta/\nu z)}$ at the short-time stage with $x = t/t_m \ll 1$, whereas it asymptotically approaches unity, $F_m(x \gg 1) \to 1$, at the long-time stage with $x = t/t_m \gg 1$. Values of dynamical critical exponents z = 2,035(4), θ' = 0.490(1), and exponent k= 1.340(4) were calculated. These values of exponents are more authentic in comparison with obtained before by another methods (see [5]).

Aging effects have been revealed during study of two-time dependence of the autocorrelation function on different initial states which are characterized by the slowing down in the correlation of the system with the growth of its age t_{w}. We show that the slowing down of the autocorrelation function during evolution from high-temperature initial state is considerably more slow than for case of evolution from low-temperature initial state. It was established realization of scaling relation for the autocorrelation function in form $C(t,t_w,t_m) \sim t^{-2\beta/(\nu z)} F_C(t/t_w, t/t_m)$, where scaling function $F_C(t/t_w, t/t_m)$ is finite at $t_{\mathrm{w}} \to 0$ and $t/t_m \to 0$. We give graphic presentation of the scaling function dependence on t/t_{w} for different initial states and calculate an exponents characterizing asymptotical behavior of the scaling function in long-time stage with $t/t_{\mathrm{w}} >> 1$.

The reported study was funded by RFBR according to the research projects № 17-02-00279, 18-42-550003 and grant MD-6868.2018.2 of the President of the Russia.

1. *V.V. Prudnikov, P.V. Prudnikov, and M.V. Mamonova*, Phys. Usp., **60**, 762 (2017).
2. *V.V. Prudnikov, P.V. Prudnikov, and E.A. Pospelov,* J. Stat. Mech., **2016**, 043303 (2016).
3. *V.V. Prudnikov, P.V. Prudnikov, E.A. Pospelov, and A N. Vakilov,* Phys. Lett. A **379**, 774 (2015).
4. *P.V. Prudnikov, V.V. Prudnikov, E.A. Pospelov, and P.N. Malyarenko*, PTEP, **2015**, 053A01 (2015).
5. *H.A. Fernandes, R. da Silva, and J.R.D. de Felпcio,* J. Stat. Mech., **2006**, P10002 (2006).