Numerical investigation of the critical behavior of the three-dimensional Ising model near the percolation threshold

MARIA A. SHLYAKHTICH[1], PAVEL V. PRUDNIKOV[2], ALEXANDR S. PAPUSHIN[2]

[1]Siberian Federal University, Theoretical Physics and Wave Phenomena Department, Krasnoyarsk, Russia

[2]Dostoevsky Omsk State University, Theoretical Physics Department, Omsk, Russia

mmed@mail.ru

The question of how disorder modifies a phase transition is still not fully resolved, not with standing decades of research. Many issues remain open, even in the case of the ferromagnetic transition in the presence of quenched disorder, from the qualitative nature of the ordered phase near criticality [1,2].

The description of phase transitions is considered to be one of the most complex and urgent problems of statistical physics. The anomalously large and long-lived fluctuations of some thermodynamic quantities observed as the phase transition point approaches are characterized by strong interactions, which creates considerable difficulties in the analytical and experimental investigation of critical behavior. Computer simulation is an independent tool for investigating the abnormal behavior of a second-order phase transition [3,4], as evidenced by the progress in the development of various methods of computer simulation. Therefore, one of the important tasks is the development of computer simulation methods that depend weakly on the effects of critical slowdown.

In recent years, the study of various disordered models near the threshold of impurity percolation has become an actual and interesting problem [5,6]. In this paper we have investigated the critical properties of the Ising model near the percolation threshold. At a concentration close to critical, a cluster appears that connects the opposite sides of the lattice. At the critical concentration $p = p_c$, the largest cluster has a fractal dimension. In the theoretical description of the behavior of such systems, the concentration of defects by a small quantity can no longer be considered. That makes their theoretical description very difficult or even impossible. A Invaded cluster algorithm was proposed in [7], which is much more effective than all previous methods near the impurity percolation threshold.

In this work we investigate the critical behavior of the disordered three-dimensional Ising model with an impurity concentration close to the threshold of impurity percolation on high-performance computing systems.

This research was supported by the grants 17-02-00279, 18-42-55003 of Russian Foundation of Basic Research and by the grants MD-6868.2018.2 of Russian Federation President.

The simulations were supported in through computational resources provided by the Shared Facility Center “Data Center of FEB RAS” (Khabarovsk), by the Supercomputing Center of Lomonosov Moscow State University, by Moscow Joint Supercomputer Center and by St. Petersburg Supercomputer Center of the Russian Academy of Sciences.

[1] G. Tarjus and Vik. Dotsenko, J. Phys. A, (2002) 35, 1627.
[2] F. Krzakala, F. Ricci-Tersenghi, D. Sherrington, and L. Zdeborová, J. Phys. A, (2011) 44, 042003.
[3] V.V. Prudnikov, P.V. Prudnikov, A.S. Krinitsyn, et. al., Phys. Rev. E, (2010) 81, 011130.
[4] P.V. Prudnikov, M.A. Medvedeva, Progr. Theor. Phys., (2012) 127, 369.
[5] I. Balog, K. Uzelac, Phys.Rev.E, (2007) 76, 011103.
[6] E. Faraggi, Phys.Rev.B, (2008) 78, 134416.
[7] J. Machta, Y.S. Choi, A. Lucke, T. Schweizer, Phys.Rev.Lett., (1995) 15, 2792.