Aging and non-equilibrium critical phenomena in Monte Carlo simulations

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The collective behaviour of statistical systems close to critical points is characterized by an extremely slow dynamics which, in the thermodynamic limit, finally prevents them from relaxing to an equilibrium state after a change in some thermodynamic parameters. The non-equilibrium evolution following this change displays some of the features typically observed in glassy materials, such as ageing and violation of the fluctuation-dissipation theorem (FDT)[1]. It can be monitored through determination of dynamic susceptibilities and correlation functions of the order parameter, the scaling behaviour of which is characterized by universal exponents, scaling functions, and amplitude ratios. This universality allows one to calculate these quantities in suitable simplified models and Monte Carlo methods are a natural way for this analysis. We review here some of the theoretical results of computations that have been obtained in recent years for universal quantities, such as the fluctuation-dissipation ratio, associated with the non-equilibrium critical dynamics, with particular focus on the 3D pure and diluted Ising models with Glauber dynamics.

We analyse an influence of critical fluctuations, different non-equilibrium initial states and presence of nonmagnetic impurities in spin systems on two-time dependence of correlation and response functions on characteristic time variables as waiting time t_w and time of observation $t - t_w$ with $t > t_w$. It is demonstrated the two ways of Monte Carlo calculations of response functions with application of small external random magnetic fields and without its through calculation of some complicated correlation functions [2]. We discuss the obtained values of non-equilibrium exponents for autocorrelation and response functions and values of the universal long-time limit of the critical fluctuation-dissipation ratio X^{∞}. Analysis of simulation results show that the insertion of disorder leads to new values of with $X^{\infty}_{\rm diluted} > X^{\infty}_{\rm pure}$.

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