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Monte Carlo Simulation of 2D Ising Spin Glass with Power Law Decaying Interaction

Habte Dulla Berry and Pooran Singh
Department of Physics, College of Natural Sciences, Addis Ababa University, P.O.Box 1176, Ethiopia

We study distance dependent interaction coupling in 2D in order to show how a spin glass phase transition occurs when couplings between far away spins are permitted. We consider Edwards-Anderson Ising spin glass model[1,2,3]. The interaction coupling is a quenched random variable whose probability of being non-zero decays with distance between two spin sites. That means we assume that two spins s_i and s_j at the spin site i and j respectively and compute the distance between them i.e. $r_{ij} = |r_i - r_j|$[4,5]. Therefore the interaction coupling is random and its probability distribution is decaying with the distance between the spins($p(J_{ij}) \propto r_{ij}^{-\rho}$))[4]. In the model, we study changing of ρ among three different regimes. As ρ is large the power-law is decaying rapidly and only bonds with neighboring site are plausible. We study the 2D case, in which no spin glass transition exists and the interactions are short-range. But when the value of ρ is not large, there is a probability to get interaction coupling. We check the existence of spin glass phase for $\rho > 2+D$ where the system critical behavior starts being long-range rather than short-range. For $4/3D < \rho < 2+D$ there will be a phase transition but the system is out of the range of the validity of mean-field theory and for $\rho < 4/3D$ (mean-field critical behavior). Therefore, to probe the critical behavior one must resort to other approaches. One useful approach is numerical simulation, which is the theme of this work.

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