Pushing the Limits of Monte Carlo Simulations for the 3d Ising Model

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— While no analytic solution for the 3d Ising model exists, various numerical methods like series expansion, Monte Carlo and MCRG have provided precise information about the phase transition.\(^1\) Using histogram techniques and quadruple precision Monte Carlo simulation that employs the Wolff cluster flipping algorithm with both 32-bit and 53-bit random number generators, we have investigated the critical behavior of the 3d Ising Model, with lattice sizes ranging from \(16^3\) to \(1024^3\). By analyzing data with cross-correlations\(^2\) between various thermodynamic quantities obtained from the same data pool, e.g. logarithmic derivatives of magnetization and derivative of magnetization cumulant,\(^3\) we have obtained the critical inverse temperature \(K_c = 0.221\,654\,626(5)\) and the critical exponent of the correlation length \(\nu = 0.629\,73(14)\) whose precisions are comparable to those from the latest theoretical predictions.

\(^1\)For an overview of earlier work, see A. Pelissetto and E. Vicari, Phys. Rep. 368, 549 (2002)