Monte-Carlo simulations of the directional-ordering transition in the classical and quantum compass model in two dimensions

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We report on a comprehensive study of the compass model on the square lattice for classical and quantum spin degrees of freedom using Monte Carlo and Quantum Monte Carlo methods. We employ state-of-the-art implementations using Metropolis, Stochastic Series Expansion and Parallel Tempering techniques to obtain the critical ordering temperatures and critical exponents. In a pre-investigation we reconsider the classical compass model where we study and contrast the finite-size scaling behaviour of ordinary periodic boundary conditions against annealed boundary conditions. We show that periodic boundary conditions suffer from extreme finite-size effects which might be caused by closed loop excitations wrapping around the torus. These excitation also appear to have severe effects on the Binder parameter. On this footing we report on the first systematic Monte Carlo study of the quantum compass model. Our numerical results are at odds with a recent Letter and we trace back the discrepancy to neglecting the finite-size effects on periodic lattices. The data analysis supports a transition in the 2D Ising universality class for both the classical and the quantum model.

[1] T. Tanaka and S. Ishihara, Phys. Rev. Lett. **98**, 256402 (2007).
[2] D. Khomskii and M. Mostovoy, J. Phys. A, **36**, 9197, (2003).
[3] B. Douçot, M. V. Feigel'man, L. B. Ioffe, and A. S. Ioselevich, Phys. Rev. B **71**, 024505 (2005).
[4] A. Mishra *et al.*, Phys. Rev. Lett. **93**, 207201 (2004).
[5] S. Wenzel and W. Janke, preprint (2008).