Phase Transitions in an Artificial Spin Ice Model
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Artificial spin ices (ASI) are geometrically frustrated arrays of magnetic nanoislands, originally designed to mimic the behavior of pyrochlore spin ice materials. Different types of ASI have been developed lately, giving rise to interesting phenomena such as magnetic monopole-like excitations and vertex frustration, as well as suggesting the possibility of new applications. A novel geometry of ASI recently proposed in the literature [1] has been termed “rewritable” artificial spin ice, for it allows total control over the microstates of the system at room temperature. Although the reported experimental realization of this particular system is essentially athermal, recent techniques permit the fabrication of nanoislands susceptible to thermal fluctuations, which makes it important to investigate the thermal behavior of ASI. We have performed Monte Carlo simulations of a model of the rewritable ASI, with nanoislands being treated as Ising macrospins with dipolar interactions, in order to study its phase transitions in the absence of a magnetic field. Both periodic and open boundary conditions have been considered. The ground state has been determined to be maximally magnetized, and an ordered phase has been observed at low temperatures. In the thermodynamic limit, a continuous transition between this ordered phase and a disordered one—in which monopole-like excitations are present—is clearly evidenced by the divergence of the specific heat curve at the critical temperature. In finite systems, however, a low temperature pseudo-phase transition takes place, introducing an intermediary phase between the disordered and the fully magnetized phases which is almost free of excitations and shows low net magnetization values. The pseudo-critical temperature has been determined by means of a new method based upon the energy probability distribution zeros [2]. In future works, we intend to further investigate the nature of this pseudo-transition. We acknowledge financial support from CNPq and FAPEMIG.