Dimensional crossover in critical behavior of ultrathin magnetic films

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An understanding of critical phenomena in low dimensional structures can be acquired from a study of ultrathin films in which one dimension, the film thickness N, is systematically reduced. The magnetic behavior of ultrathin films has become of great technological importance due to the applications in magnetic storage devices [1]. Magnetic order in ultrathin ferromagnetic films is very complex due to a strong influence of the shape and the magnetocrystalline anisotropies of the sample. In the past 20 years, a considerable amount of experimental results on different aspects of magnetism in ultrathin films has appeared [2]. Nevertheless it is difficult to reach general conclusions even in seemingly basic things such as the kind of magnetic order at low temperatures. In view of this complexity, theoretical work on simplified models and computer simulations are essential for rationalizing and guiding new experimental work.

In this study, our aim is to give a complete picture of the magnetic phase transition in thin films structures. We have studied the magnetic behavior of anisotropic Heisenberg thin films [3] using extensive Monte Carlo simulations. We have found the dimensional crossover of magnetization m and susceptibility χ from 2D to 3D like with increasing film thickness. Estimated values of the critical exponent β for different thickness demonstrates crossover from 2D Ising universality class to 3D Heisenberg through 3D Ising class.

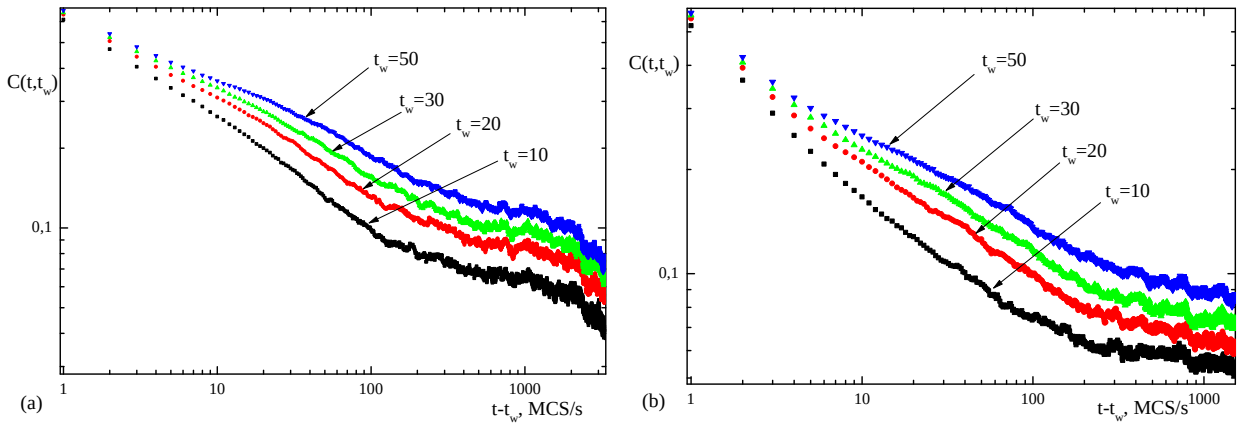

Fig.1 Aging in autocorrelation function $A(t, t_w)$ for (a) $N = 2$ and (b) $N = 4$

Presence of surfaces breaks lattice symmetries, and this can lead to many surprising and unexpected effects out of equilibrium [4]. The influence of non-equilibrium initial states on critical dynamic behavior of ultrathin magnetic and metamagnetic films have studied by short-time dynamics method [5]. Aging effects were discovered for non-equilibrium regime $t - t_w \gg t_w$ (Fig.1).

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