Dipolar interactions and critical behavior in two dimensional ferromagnets: an avoided phase transition scenario

Sergio Cannas
Universidad Nacional de Córdoba, Argentina

The paramagnetic-to-ferromagnetic phase transition is classified as a critical phenomenon due to the power-law behavior shown by thermodynamic observables when the Curie point is approached. In this work we report the observation of such behavior over many decades of suitable scaling variables in ultrathin Fe films, for certain ranges of temperature $T$ and applied field $B$. Moreover, both scaling functions and critical exponents agree with those corresponding to the two dimensional Ising model (Onsager). This despite the fact that the underlying critical point is completely unreachable because protected by a phase with a modulated domain structure, induced by dipole-dipole interaction. Monte Carlo simulations on a two dimensional Ising model with both ferromagnetic exchange interactions and dipolar interactions support the experimental results, showing the same scaling behavior associated with a temperature $T_c$ that converges to the Onsager value in the limit if dipolar interactions going to zero. In both cases (experiments and simulations) the modulated phase is realized in a portion of the $(T,B)$ plane that extend above the putative critical temperature, where the thermodynamic quantities show no singularity. We show that a generalized scaling with the dipolar coupling allows to interpret such avoided criticality scenario as a crossover phenomenon between a short range (i.e., exchange) dominated regime to a dipolar (i.e., with modulated domains) dominated one. Such scaling hypothesis is supported by Mean Field, Real Space Renormalization Group and Monte Carlo calculations.