Contribution ID: **255** Type: **not specified**

Critical Temperatures of Finite Samples at Finite Observation Times

Monday, February 15, 2010 2:00 PM (1 hour)

The correlation function is an essential ingredient of any theory of phase transitions, covering electronic systems, liquids or magnets, since it provides direct information on critical properties of a system. With the Ornstein-Zernike law its general analytical form is known for infinite systems at infinite observation times, above the critical temperature.

However, important experimental developments involve ever smaller length- and time-scales connected with size- and time-dependent phases like thermally assisted switching of magnetization. For such nano-sized systems, there is up to now no clear understanding of crossover phenomena like the crossover from a paramagnetic state at high temperatures via a superparamagnetic regime to ferro- or antiferromagnetic order at low T, and how they manifest themselves in the correlation function. This is related to the problem that a Curie (or Neel) temperature cannot be defined unambiguously. These problems hamper a reliable interpretation of experimental results.

In this talk I will present a particularly simple general expression for the correlation function, covering all sample sizes L, all observation times, and the entire temperature range from zero to infinity. Our numerical and analytical calculations demonstrate that the Curie temperature does not simply decrease with decreasing sample size but rather splits in finite samples for finite observation times. This new result obtained for open boundaries does not violate scaling invariance and recovers all known laws for periodic boundary conditions, infinite observation times and high temperatures as limiting cases. The proposed form for the correlation function allows for a novel and effective procedure to determine above mentioned splitting and critical temperatures which goes beyond the famous Binder cumulants method as it permits an accurate determination of the Curie temperature of infinite and finite objects, as well as the blocking temperature, from a single calculation of a finite object without tedious finite-size scaling.

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