ABSTRACTS

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Finite-Size Effects at Phase Transitions

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Unconventional types of phase transitions due to interplay of finite size and interfacial effects

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As generic system for confined nano systems, Ising models are considered confined between "competing walls" on which surface fields of opposite sign act. Such systems do not acquire a nonzero total magnetization at the transition temperature of the bulk, since domains of opposite magnetization are stabilized. At a lower temperature, a magnetization appears, discontinuously, in the thermodynamic limit, though this transition can be the limiting case of a second order transitions. Depending on the geometry, this transition is related to wetting corner filling, or cone filling transitions. Phenomenological finite size scaling concepts about these transitions are discussed, and evidence from Monte Carlo simulations is presented. The double-pyramide geometry can be modeled by a Landau-type free energy, but with size-dependent coefficients.

Successes and limitations of current renormalization group approaches to the study of finite-size effects

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A survey of what current renormalization group (RG) approaches based on expansions about the upper critical dimension can contribute to the study of finite size effects near continuous bulk phase transitions is given. In particular, systems in slab geometries – the simplest geometries encountered in studies of the Casimir effect – are considered. Recent work [1,2] revealing that previous approaches break down at the bulk critical temperature T_c in those cases where the boundary conditions entail the presence of a zero mode at the level of Landau theory is elucidated. The proposed reorganization of RG-improved perturbation theory makes the theory well-defined at T_c and yields temperature dependent scaling functions in conformity with phenomenological analyticity requirements. This improves the theory for slabs under such "zero-mode boundary conditions" basically to the level known from the cases of boundary conditions for which no zero modes are present at T_c in Landau theory. The challenge to go beyond this level by developing successful feasible approximation schemes by which the finite size behavior can be systematically studied for slabs also for temperatures below T_c, including eventual dimensional crossovers, remains.

[1] H. W. Diehl, D. Grüneberg, and M. A. Shpot, *Europhys. Lett.* **75**, 241 (2006) [cond-mat/0605293].

[2] D. Grüneberg, H. W. Diehl, and D. M. Dantchev, to be published.

Thermodynamic Casimir forces

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Long-ranged correlations in a fluid near its critical point lead to clearly identifiable effective forces acting on confining walls. The corresponding universal scaling functions are discussed for different boundary conditions and geometries. The theoretical predictions are compared with high precision experimental data for ^{4}He and ^{3}He/^{4}He wetting films near the superfluid phase transition as well as with synchrotron scattering data from classical binary liquid mixtures. Applications for colloidal suspensions are discussed.

Diversity of critical behavior within a universality class

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The notion of a universality class of critical phenomena in bulk and confined systems is discussed. The Privman-Fisher hypothesis [1] states that, for given geometry and boundary conditions, finite-size scaling functions are universal, i.e., independent of microscopic details, and that two-scale factor universality is valid for confined systems. In recent years it has been shown that renormalization-group (RG) theory is well compatible with a certain degree of diversity of finite-size critical behavior within a universality class. There are at least two microscopic sources of nonuniversal effects near criticality: (i) van der Waals type interactions in fluids and (ii) anisotropic interactions in solids. While critical exponents are not affected by these sources, a nontrivial dependence of finite-size scaling functions on these sources has been predicted [2, 3]. New RG results of the anisotropic φ^4 theory are presented that illustrate the nonuniversality of finite-size critical behavior. Recent MC simulations [4] for anisotropic Ising models support this diversity.

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Spin dynamics simulations of excitations and critical dynamics in a Heisenberg antiferromagnet: Resolution of a controversy via finite size scaling

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The classic Halperin-Hohenberg classification of "dynamic" universality classes separates models with stochastic and deterministic behavior. Stochastic, e.g. Ising, models have long been studied using Monte Carlo simulations but research on magnetic systems with true dynamics is less detailed because of limitations in both computer speed and algorithms. Spin dynamics simulation methods have developed sufficiently that they now provide a powerful tool for the examination of excitations and dynamic critical behavior in magnetic models. From the Fourier transform of the space-displaced, time-displaced correlation functions the dynamics structure factor $S(q, \omega)$ can be extracted. After briefly describing modern decomposition methods for the time integration we shall present results for a classical, Heisenberg antiferromagnet on a simple cubic lattice. This model is an excellent "testing ground" since it is expected to describe the magnetic behavior of $RbMnF_3$ quite well. The estimation of the dynamic critical exponent z is non-trivial and relies on finite size scaling of the dynamic structure factor. We shall compare our results with theoretical predictions as well as with detailed neutron scattering data.

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