DY 42: Critical Phenomena and Phase Transitions

Time: Friday 10:15–12:45 Location: ZEU 255

DY 42.1 Fri 10:15 ZEU 255

Ground states of random-field Ising magnets with correlated disorder — •Björn Ahrens and Alexander K. Hartmann — Universität Oldenburg

We consider the random-field Ising magnet (RFIM) in $d = 3$ with correlated disorder. The RFIM consists of ferromagnetically coupled Ising spins with an additional quenched local random field. To ensure unique ground states the random field is chosen to be distributed according to a Gaussian with zero mean and a tunable standard deviation. Using Fourier transforms, we generate correlated random fields which exhibit a power-law shaped two-point correlation function. This well known method conserves the Gaussian distribution of the random field.
To obtain the ground state for each realisation of the disorder numerically, we map the random field to a graph with suitable chosen edge capacities [Picard and Ratliff, Networks 5, 357 (1975)]. For these graphs we calculate the maximum flow using a fast polynomial max-flow/min-cut algorithm, recently developed in algorithmic graph theory. Therein the minimum cut corresponds to a ground state configuration of the system. This allows to calculate exact ground states of systems up to $N = 100^3$ spins.
Similar to the RFIM with uncorrelated Gaussian disorder we find phase transitions for different two-point correlation functions. We obtain critical scaling exponents to analyse the transitions, using finite-size scaling.

DY 42.2 Fri 10:30 ZEU 255

Delocalized-localized transition of disordered phonons — •Sebastian Pinski and Rudolf Römer — Department of Physics and Centre for Scientific Computing, University of Warwick, Coventry, CV4 7AL, United Kingdom

The Anderson model (AM) of localization has been a major topic of research for over 50 years. The resemblance of this model with that of the 'scalar' model of phonon localization (SMPL) due to disorder has been noted, yet only probed in 1D systems. Past research on the SMPL has been heavily directed towards the vibrational density of states and unearthing the origins of the boson-peak, with the delocalized-localized transition assumed to be close to the upper band edge. We present work on a equivalence relation between the AM and the SMPL that has enabled direct translation of the electron phase diagram with onsite potential disorder to that of a phonon phase diagram with mass disorder. This has been verified with high accuracy transfer matrix method (TMM) calculations. Phononic phase diagrams for both mass and force-constant disorder in the SMPL are presented for the first time and the implications of these diagrams are discussed. Finally, finite size scaling of the results obtained from TMM indicates that the critical exponent of phononic systems is similar to that of electronic systems.

DY 42.3 Fri 10:45 ZEU 255

Migdal-Kadanoff approximation to the diluted negative-weight percolation problem — •Oliver Melchert[1], Stefan Boettcher[2], and Alexander K. Hartmann[1] — [1]Institut für Physik, Carl-von-Ossietzky Universität Oldenburg, Oldenburg (Germany) — [2]Department of Physics, Emory University, Atlanta (USA)

We consider the diluted negative weight percolation (NWP) problem [1] on lattice graphs, wherein edge weights are drawn from disorder distributions that allow for weights of either sign. We are interested whether there are system-spanning paths or loops of total negative weight. So as to study the model on hypercubic lattice graphs numerically, one has to perform a non-trivial transformation of the original graph and apply sophisticated matching algorithms.

Here, we consider the NWP model on hierarchical lattice graphs, where a Migdal-Kadanoff (MK) approximation can be used to gain insight on the topology of the phase diagram. For a very basic disorder distribution we set up a renormalization group (RG) transformation and study the RG flow in the disorder-dilution plane in order to find fixed points and critical indices for the linearized model. We further implement the "pool" method [2] to yield the phase diagram and critical exponents upon decimation of huge graphs and we compare our findings to previous results from finite-size scaling analyses [1,3].

[1] L. Apolo, OM, and A.K. Hartmann, Phys. Rev. E 79 (2009) 031103
[2] S. Boettcher, Eur. Phys. J. B 33 (2003) 439
[3] OM, L. Apolo, and A.K. Hartmann, Phys. Rev. E 81 (2010) 051108

DY 42.4 Fri 11:00 ZEU 255

A numerical study of self-avoiding walks (SAWs) on disordered two-dimensional lattices — •Niklas Fricke and Wolfhard Janke — Institut für Theoretische Physik, Universität Leipzig, Germany

We revisit the long-standing problem of SAWs on diluted two-dimensional lattices at and above the percolation threshold, employing a Monte Carlo algorithm as well as a newly developed complete enumeration technique.

Some of the results are quite surprising, as they are in conflict with the Meir-Harris model [1], which is generally assumed to provide the qualitatively correct description for the scaling behaviour of SAWs on disordered lattices.

The widely held conviction that the exponents on the backbone are the same as on the full percolation cluster is also put under scrutiny.

[1] Y. Meir and A. B. Harris, Phys. Rev. Lett. 63, 26 (1989)

DY 42.5 Fri 11:15 ZEU 255

Speeding up critical system dynamics through optimized evolution — •Tommaso Caneva[1], Tommaso Calarco[1], Rosario Fazio[3], Giuseppe E. Santoro[2,4,5], and Simone Montangero[1] — [1]Institut für Quanteninformationsverarbeitung, Universität Ulm, D-89069 Ulm, Germany — [2]International School for Advanced Studies (SISSA), Via Beirut 2-4, I-34014 Trieste, Italy — [3]NEST, Scuola Normale Superiore & Istituto di Nanoscienze - CNR, Piazza dei Cavalieri 7, I-56126 Pisa, Italy — [4]CNR-INFM Democritos National Simulation Center, Via Beirut 2-4, I-34014 Trieste, Italy — [5]nternational Centre for Theoretical Physics (ICTP), P.O.Box 586, I-34014 Trieste, Italy

The number of defects which are generated on crossing a quantum phase transition can be minimized by choosing properly designed time-dependent pulses. In this talk we show what are the ultimate limits of this optimization. We discuss under which conditions the production of defects across the phase transition is vanishing small. Furthermore we show that the minimum time required to enter this regime is $T = \pi/\Delta$, where Δ is the minimum spectral gap, unveiling an intimate connection between an optimized unitary dynamics and the intrinsic measure of the Hilbert space for pure states. Surprisingly, the dynamics is non-adiabatic; this result can be understood by assuming a simple two-level dynamics for the many-body system.

DY 42.6 Fri 11:30 ZEU 255

Critical Parameters from a Generalized Multifractal Analysis at the Anderson Transition — Alberto Rodriguez[1], Louella J Vasquez[1], Keith Slevin[2], and •Rudolf A Römer[1] — [1]Dept. of Physics and Ctr for Scientific Computing, University of Warwck, Coventry, CV4 7AL, UK — [2]Department of Physics, Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan

We propose a generalization of multifractal analysis that is applicable to the critical regime of the Anderson localization-delocalization transition. The approach reveals that the behavior of the probability distribution of wave function amplitudes is sufficient to characterize the transition. In combination with finite-size scaling, this formalism permits the critical parameters to be estimated without the need for conductance or other transport measurements. Applying this method to high-precision data for wave function statistics obtained by exact diagonalization of the three-dimensional Anderson model, we estimate the critical exponent $\nu = 1.58 \pm 0.03$.

DY 42.7 Fri 11:45 ZEU 255

The infinite-component spin glass revisited — •Frank Beyer and Martin Weigel — Institut für Physik, KOMET 331, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, 55127 Mainz

Starting from the Sherrington-Kirkpatrick (SK) mean-field spin-glass model with a broken replica symmetry, an expansion towards finite (spatial) dimensions ($d = 2, 3, \ldots$) breaks down at the upper critical dimension. One way of bypassing these problems might be to consider the replica-symmetric m-component vector spin glass in the limit $m \to \infty$ and attempt an expansion towards the finite-m cases including the XY and Heisenberg spin glass. In this contribution, we study vector spin glasses in the $m \to \infty$ limit using ground-state calculations at zero temperature and a saddle-point approximation at finite temperatures. For the SK model, we show the existence of a finite order parameter in the ordered phase and critical scaling behavior consistent with an upper critical dimension equal to eight. Using ground-state calculations, we determine the lower critical dimension to be $5 \leq d_l \leq 6$ when the limit $m \to \infty$ is taken before the thermodynamic limit $N \to \infty$, while we find indications for $d_l = 3$ for the opposite (physical) order of taking limits. Complementing these results, we studied a one-dimensional chain with power-law decay of interactions that can be continuously tuned from the mean-field to the short-range regime.

DY 42.8 Fri 12:00 ZEU 255

Aspect ratio dependence of critical Casimir forces — •Alfred Hucht, Daniel Grüneberg, and Felix Schmidt — Fakultät für Physik, Universität Duisburg-Essen

We consider three-dimensional Ising models in a $L_\perp \times L_\parallel \times L_\parallel$ cuboid geometry with finite aspect ratio $\rho = L_\perp / L_\parallel$ and periodic boundary conditions along all directions. For these models the universal finite-size scaling function of the thermodynamic Casimir force is evaluated numerically by means of Monte Carlo simulations employing the method recently presented in [1]. The Monte Carlo results are compared to recent field theoretical results for the Ising universality class for temperatures below and above the bulk critical temperature T_c [2], and to the finite-size scaling functions of the thermodynamic Casimir force derived in [3] for the $O(n)$-symmetrical case and temperatures $T \geq T_c$ in the framework of the renormalization group-improved perturbation theory to two-loop order. The MC data are found to be in good agreement with these field theoretical results. Furthermore, the Casimir force scaling function for the two dimensional Ising model as function of ρ is calculated exactly and compared to the three dimensional case.

[1] A. Hucht, Phys. Rev. Lett. 99, 185301 (2007). [2] V. Dohm, Europhys. Lett. 86, 20001 (2009). [3] D. Grüneberg and H. W. Diehl, Phys. Rev. B, 77, 115409 (2008).

DY 42.9 Fri 12:15 ZEU 255

Critical Casimir forces in the presence of a chemically structured substrate — •Francesco Parisen Toldin[1] and Siegfried Dietrich[2,3] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden, Germany — [2]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart, Germany — [3]Institut für Theoretische und Angewandte Physik, Universität Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany

Motivated by recent experiments on a binary liquid mixture, we study the critical properties of a system in the Ising universality class, in a film geometry in the presence of a chemically structured substrate, with alternating adsorption preference. By means of Monte Carlo simulations of an improved Hamiltonian, so that the leading scaling corrections are suppressed, numerical integration, and finite-size scaling analysis we determine the critical Casimir force and its universal scaling function.

DY 42.10 Fri 12:30 ZEU 255

Optimizing Wilson's Momentum Shell Renormalization Group — •Andreas Troester — Johannes Gutenberg University, Mainz, Germany

Previous attempts to accurately compute critical exponents from Wilson's momentum shell renormalization prescription suffered from the difficulties posed by the presence of an infinite number of irrelevant couplings. Taking the example of the 1d long-ranged Ising model [A. Tröster, PRE **79**, 036707 (2009)], we calculate the momentum shell renormalization flow in the plane spanned by the coupling constants (u_0, r_0) by a simulation method based on our recently developed Fourier Monte Carlo algorithm [A. Tröster, PRB **76**, 012402 (2007); PRL **100**, 140602 (2008); Comput. Phys. Comm. **179**, 30 (2008)]. Carrying out such simulations for different values of the momentum shell thickness parameter b, we report strong anomalies in the b-dependence of the fixed point couplings and the resulting exponents y_τ and ω in the vicinity of a shell parameter $b^* < 1$ characterizing a thin but finite momentum shell. Evaluation of the exponents for this "optimized" value b^* of b yields a dramatic improvement of their numerical accuracy, indicating a strong damping of the influence of irrelevant couplings [A. Tröster, Phys. Rev. B **81**, 125135 (2010); Comput. Phys. Comm., accepted for publication (2010)].