DY 26: Critical Phenomena and Phase Transitions

Time: Wednesday 10:00–11:30 Location: H20

DY 26.1 Wed 10:00 H20

Percolation properties of the Ising spin glass in two dimensions — •Lambert Münster and Martin Weigel — Institut für Physik, TU Chemnitz, 09107 Chemnitz, Germany

Cluster representations provide a framework to study critical phenomena from the geometrical perspective of percolation. Due to frustration the common Fortuin-Kasteleyn cluster representation of ferromagnets is not well suited to describe the spin-glass transition [1,2]. The order parameter of this transition is the overlap which is naturally defined with respect to two replicas. In the present work we hence study a two-replica cluster representation [3] of the two-dimensional Ising spin glass by performing Monte Carlo simulations at low temperatures. Our data is consistent with the existence of a zero-temperature percolation transition in agreement with the zero-temperature spin-glass transition in two dimensions. The overlap is proportional to the difference in density of the two largest clusters.

[1] V. Cataudella, G. Franzese, M. Nicodemi, A. Scala, and A. Coniglio, Phys. Rev. Lett. **72**, 1541, (1994).
[2] H. Fajen, A. K. Hartmann, and A. P. Young, Phys. Rev. E **102**, 012131, (2020).
[3] J. Machta, C. M. Newman, and D. L. Stein, J. Stat. Phys. **130**, 113, (2008).

DY 26.2 Wed 10:15 H20

Replica-symmetry breaking for directed polymers in correlated random media — •Alexander K. Hartmann — Institute of Physics, University of Oldenburg

The phase-space behavior of complex system can often be described by *replica-symmetry breaking* (RSB), as introduced by Giorgio Parisi for mean-field Ising spin glasses [1] and highlighted by the Nobel price 2021. Numerically, spin glasses and related problems are notoriously hard to study, such that models exhibiting RSB have been treated so far only for small sizes. Here, directed polymers on 1+1 dimensional lattices at temperature T are considered [2]. New ensembles with correlations of the disorder as well as fractal patterning are introduced [3]. This model allows for direct sampling in perfect thermal equilibrium for large system sizes of $N = L^2 = 32768 \times 32768 \approx 10^9$ sites. Fluctuations of the free energy and transverse extension are obtained and compared with the standard uncorrelated ensemble. The phase-space structure is studied via the distribution of overlaps, hierarchical clustering methods and analysis of ultrametricity. One ensemble shows a simple behavior like a ferromagnet. The other two ensembles exhibit indications for multiple RSB. In total, the present model ensembles offer convenient numerical access to comprehensively studying complex RSB-like behavior.
[1] G. Parisi, Phys. Rev. Lett. **43**, 1754 (1979)
[2] A. K. Hartmann, Big Practical Guide to Computer Simulations, World-Scientific, Singapore (2015)
[3] A. K. Hartmann, Euro. Phys. Lett. **137**, 41002 (2022)

DY 26.3 Wed 10:30 H20

Interplay of disorder and flat band geometry for generalized Lieb models in 3D with correlated order — •Jie Liu[1], Carlo Danieli[2], Jianxin Zhong[1], and Rudolf A. Römer[1,3,4] — [1]School of Physics and Optoelectronics, Xiangtan University, Xiangtan 411105, China — [2]MPI-PaKS, Nöthnitzer Strasse, Dresden, Germany — [3]Department of Physics, University of Warwick, Coventry, CV4 7AL, United Kingdom — [4]CY Advanced Studies and LPTM (UMR8089 of CNRS), CY Cergy-Paris Université, F-95302 Cergy-Pontoise, France

Uniform Anderson disorder in generalized 3D Lieb models gives rise to the existence of bounded mobility edges and destroys the macroscopic degeneracy of the compactly-localized states. We now introduce correlated order such that this degeneracy remains and the compactly-localized states are preserved. We obtain the energy-disorder phase diagrams via transfer matrix methods, computing the localization lengths and via sparse-matrix direct diagonalization, using r-value energy-level statistics. For suitably large disorders, we can finite-size scale both quantities and identify mobility edges with critical properties close to the standard Anderson transition in 3D. Intriguingly, the survival of the compactly-localized states lead to seemingly diverging mobility edges. For small disorder, however, a change from extended to localized behavior can be found upon decreasing disorder — leading to an unconventional "inverse Anderson" behavior.

DY 26.4 Wed 10:45 H20

Anomalous collective dynamics of auto-chemotactic populations — Jasper van der Kolk[1], •Florian Rasshofer[1], Richard Swiderski[1], Astik Haldar[2], Abhik Basu[2], and Erwin Frey[1,3] — [1]Arnold Sommerfeld Center for Theoretical Physics and Center for NanoScience, Department of Physics, Ludwig-Maximilians-Universität München, Theresienstraße 37, D-80333 Munich, Germany — [2]Theory Division, Saha Institute of Nuclear Physics, HBNI, 1/AF Bidhannagar, Calcutta 700 064, West Bengal, India — [3]Max Planck School Matter to Life, Hofgartenstraße 8, 80539 Munich, Germany

While the role of local interactions in non-equilibrium phase transitions is well studied, a fundamental understanding of the effects of long-range interactions is lacking. In particular, we ask the question how long-ranged interactions can alter the universal behaviour close to an absorbing state. As a model system, we study the critical dynamics of reproducing agents subject to auto-chemotactic interactions and limited resources.

A renormalization group analysis reveals distinct scaling regimes for fast (attractive or repulsive) interactions; for slow signal transduction the dynamics is dominated by a diffusive fixed point. Further, we present a novel nonlinear mechanism that stabilizes the continuous transition against the emergence of a characteristic length scale due to a chemotactic collapse.

DY 26.5 Wed 11:00 H20

Population Annealing Monte Carlo Using the Rejection-Free n-Fold Way Update Applied to a Frustrated Ising Model on a Honeycomb Lattice — •Denis Gessert[1,2], Martin Weigel[1,3], and Wolfhard Janke[2] — [1]Centre for Fluid and Complex Systems, Coventry University, Coventry, CV1 5FB, United Kingdom — [2]Institut für Theoretische Physik, Leipzig University, Postfach 100920, 04009 Leipzig, Germany — [3]Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz, Germany

Population annealing (PA) is a Monte Carlo method well suited for problems with a rough free energy landscape such as glassy systems. PA is similar to repeated simulated annealing, with the addition of a resampling step at each temperature. While a large population may to some extent compensate for imperfect equilibration, it is clear that PA must fail if almost no spins are flipped during equilibration.

This is the case in systems with a phase transition at a very low temperature where a high Metropolis rejection rate makes sampling phase space near infeasible. To overcome this slow-down we propose a combination of the PA framework with the rejection-free “n-fold way” update and achieve an exponential speed-up at low temperatures as compared to Metropolis.

To test our method we study the Ising model with competing ferromagnetic ($J_1 > 0$) nearest and antiferromagnetic ($J_2 < 0$) next-to-nearest neighbor interactions on a honeycomb lattice. As T_c becomes arbitrarily small when approaching the special point $J_2 = -J_1/4$ with $T_c = 0$ we consider this a good choice to test the efficacy of our method.

DY 26.6 Wed 11:15 H20

Critical behavior of the three-state random-field Potts model in three dimensions — Manoj Kumar[1], Varsha Banerjee[2], Sanjay Puri[3], and •Martin Weigel[1] — [1]Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz, Germany — [2]Department of Physics, Indian Institute of Technology, Hauz Khas, New Delhi – 110016, India — [3]School of Physical Sciences, Jawaharlal Nehru University, New Delhi – 110067, India.

Enormous advances have been made in the past 20 years in our understanding of the random-field Ising model, and there is now consensus on many aspects of its behavior at least in thermal equilibrium. In contrast, little is known about its generalization to the random-field Potts model which has a number of important experimental realizations. Here we start filling this gap with an investigation of the three-state random-field Potts model in three dimensions. Building on the success of ground-state calculations for the Ising system, we use a recently developed approximate scheme based on *graph-cut methods* to study the properties of the zero-temperature random fixed point of the system that determines the zero and non-zero temperature transition behavior. We find compelling evidence for a continuous phase transition. Implementing an extensive finite-size scaling (FSS) analysis, we determine the critical exponents and compare them to those of the random-field Ising model.