DY 6: Critical Phenomena and Phase Transitions

Time: Monday 11:30–13:00 Location: H47

DY 6.1 Mon 11:30 H47

The square lattice Ising model with quenched surface disorder — Luca Cervellera, Oliver Oing, Jan Büddefeld, and •Fred Hucht — Fakultät für Physik, Universität Duisburg-Essen

Using exact enumeration, the Casimir amplitude and the Casimir force are calculated for the square lattice Ising model with quenched surface disorder on one surface in cylinder geometry at criticality. The system shape is characterized by the aspect ratio $\rho = L/M$, where the cylinder length L can take arbitrary values, while the circumference M is varied from $M = 4$ to $M = 54$, resulting in up to 2^{54} numerically exact free energy calculations. A careful $M \to \infty$ extrapolation shows that quenched surface disorder is irrelevant in two dimensions, but gives rise to logarithmic corrections.

DY 6.2 Mon 11:45 H47

Partition Function Zeros of the Frustrated J_1-J_2 Ising Model on the Honeycomb Lattice — •Denis Gessert[1,2], Martin Weigel[3], and Wolfhard Janke[1] — [1]Institut für Theoretische Physik, Leipzig University, 04081 Leipzig, Germany — [2]Centre for Fluid and Complex Systems, Coventry University, Coventry CV1 5FB, United Kingdom — [3]Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz, Germany

We study the partition function zeros in the complex temperature plane (Fisher zeros) and in the complex external field plane (Lee-Yang zeros) of a frustrated Ising model with competing nearest-neighbor ($J_1 > 0$) and next-nearest-neighbor ($J_2 < 0$) interactions on the honeycomb lattice. We consider the finite-size scaling (FSS) of the leading Fisher and Lee-Yang zeros as determined from a cumulant method and compare it to a traditional scaling analysis based on the logarithmic derivative of the magnetization $\partial \ln\langle|M|\rangle/\partial\beta$ and the magnetic susceptibility χ. While for this model both FSS approaches are subject to strong corrections to scaling induced by the frustration, their behavior is rather different, in particular as the ratio $\mathcal{R} = J_2/J_1$ is varied. As a consequence, an analysis of the scaling of partition function zeros turns out to be a useful complement to a more traditional FSS analysis. The scaling of the zeros convincingly shows that the system remains in the Ising universality class for $\mathcal{R}$ as low as -0.22, where results from traditional FSS using the same simulation data are less conclusive. The approach hence provides a valuable additional tool for mapping out the phase diagram of models afflicted by strong corrections to scaling.

DY 6.3 Mon 12:00 H47

Cluster percolation in the three-dimensional $\pm J$ random-bond Ising model — •Lambert Muenster and Martin Weigel — Institut für Physik, TU Chemnitz, 09107 Chemnitz, Germany

We study the relation between cluster percolation and ordering phenomena in the three-dimensional $\pm J$ random-bond Ising model with different fraction of ferromagnetic bonds by performing Monte Carlos simulations. In particular a certain type of two-replica clusters is studied [1,2]. The density of these clusters can be linked to the overlap. We start the analysis with the pure ferromagnet and demonstrate that the percolation transition maps onto the ferromagnetic phase transition. Then, we continue our analysis with the frustrated disordered ferromagnet and finally consider the spin-glass system where half of all bonds are anti-ferromagnetic and point out differences as well as similarities between the cases.

[1] J. Machta, C. M. Newman, and D. L. Stein, *J. Stat. Phys.* **130**, 113 (2008).
[2] L. Münster and M. Weigel, *Phys. Rev. E* **107**, 054103 (2023).

DY 6.4 Mon 12:15 H47

Analysis of the Mpemba effect in magnetic systems — •Janett Prehl and Martin Weigel — Technische Universität Chemnitz, Chemnitz, Deutschland

The Mpemba effect, first discovered by Mpemba and Osborne for water [1], is observed when a hot sample cools faster than an initially colder one, when both are refrigerated in the same thermal reservoir. During the last years this effect has also been found to take place in the general context of magnetic phase transitions of different orders [2 – 4]. Here, we investigate and discuss the occurrence of this non-equilibrium process for different ferromagnetic models exhibiting a phase transition at a critical temperature T_c. We aim to analyze how different initial temperatures, structural properties or updating dynamics influence the time behavior of quantities such as energy per spin $\langle e\rangle$ or the average domain length ℓ for different system sizes L to get a deeper insight in the occurring mechanism of the Mpemba effect for the systems under consideration.

[1] E.B. Mpemba and D.G. Osborn, *Phys. Educ.* **4**:172 (1969)
[2] M. Baity-Jesi, et al., *PNAS*, **116**:15350 (2019)
[3] N. Vadakkayil, S.K. Das, *Phys. Chem. Chem. Phys.*, **23**:11186 (2021)
[4] A.K. Chatterjee, S. Takada, H. Hayakawa, *Phys. Rev. Lett.*, **131**:080402 (2023)

DY 6.5 Mon 12:30 H47

Relating phase transitions of confined materials and topology of pore network — Georgiy Baroncha[1], Rustem Valiullin[1], and •Eustathios Kikkinides[2] — [1]Leipzig University, Leipzig, Deutschland — [2]Aristotle University of Thessaloniki, Thessaloniki, Griechenland

Measuring adsorption/desorption and melting/freezing transitions in porous materials is a common route to obtain information about pore structure. To describe phase transition behavior we exploit statistical network models including cooperative effects. In this way, important properties such as pore size distribution can be deduced. By constructing statistically-disordered random-brunching Bethe lattices we show that the average pore connectivity can be assessed. However, phase transitions remain insensitive to fine details of pore network, namely its topology. Further we discuss the experimental approaches to probe pore network topology.

DY 6.6 Mon 12:45 H47

Study of the de Almeida-Thouless (AT) line in the one-dimensional diluted power-law XY spin glass — •Ramana Bharadwaj Vedula — IISER Bhopal, Bhopal, India

The behavior of finite-dimensional spin glasses at low temperatures has been debated for decades, with the replica symmetry breaking (RSB) and droplet pictures offering competing explanations. This work investigates the Almeida-Thouless (AT) line in the one-dimensional power-law diluted XY spin glass model, where interactions decay as $1/r^{2\sigma}$. Tuning σ emulates dimensional changes, bridging mean-field and non-mean-field regimes.

A novel heatbath algorithm was developed to efficiently equilibrate XY spins at low temperatures. Using this, we studied phase transitions for $\sigma = 0.6$ ($< 2/3$), where clear evidence for an AT line exists, and for $\sigma = 0.75,\ 0.85$ ($> 2/3$), where the evidence weakens. Interestingly, data for $\sigma = 0.75$ and $\sigma = 0.85$ suggest finite-size effects mimic RSB-like behavior, but analysis aligns with the droplet picture.

Unlike traditional approaches, we also varied the magnetic field at fixed temperature, providing unique insights into spin glass properties. Our results show that the AT line disappears as σ increases, favoring the droplet model for low-dimensional spin glasses.