DY 8: Critical Phenomena and Phase Transitions

Time: Monday 15:00–18:15 Location: ZEU 118

DY 8.1 Mon 15:00 ZEU 118

Corner contribution to cluster numbers in the Potts model — Istvan A. Kovacs[1], Eren M. Elçi[2], •Martin Weigel[2], and Ferenc Iglói[1] — [1]Wigner Research Centre, Institute for Solid State Physics and Optics, H-1525 Budapest, P.O.Box 49, Hungary — [2]Applied Mathematics Research Centre, Coventry University, Coventry, CV1 5FB, England

For the two-dimensional Q-state Potts model at criticality, we consider Fortuin-Kasteleyn and spin clusters and study the average number N_Γ of clusters that intersect a given contour Γ. To leading order, N_Γ is proportional to the length of the curve. Additionally, however, there occur logarithmic contributions related to the corners of Γ. These are found to be universal and their size can be calculated employing techniques from conformal field theory. For the Fortuin-Kasteleyn clusters relevant to the thermal phase transition we find agreement with these predictions from large-scale numerical simulations. For the spin clusters, on the other hand, the cluster numbers are not found to be consistent with the values obtained by analytic continuation, as conventionally assumed.

DY 8.2 Mon 15:15 ZEU 118

Fragmentation of Potts clusters — •Eren M. Elçi and Martin Weigel — Applied Mathematics Research Centre, Coventry University, Coventry, CV1 5FB, England

The random cluster model is at the heart of a range of models in statistical physics, including uniform spanning trees, percolation and the Potts model. Many geometric and fractal aspects have been analysed, in particular at criticality, and a related zoo of exponents is known exactly or at least accessible by numerical methods. The fragmentation of clusters is a process of general importance for the modeling of a wide range of phenomena, including polymer fragmentation and processes in porous media. We use extensive numerical simulations employing a recent efficient implementation of Sweeny's single-bond algorithm to study the distribution of cluster sizes as well as the density of fragmenting (or bridge) bonds relevant to the fragmentation properties. The latter quantity is of additional importance for algorithmic aspects such as the observed critical speeding up of the single-bond dynamics.

DY 8.3 Mon 15:30 ZEU 118

Simulated tempering and magnetizing Monte Carlo study of crossover scaling in the 2d 3-state Potts model — Tetsuro Nagai[1], Yuko Okamoto[1], and •Wolfhard Janke[2] — [1]Department of Physics, Nagoya University, Nagoya, Aichi 464-8602, Japan — [2]Institut für Theoretische Physik, Universität Leipzig, Postfach 100 920, 04009 Leipzig, Germany

The recently introduced simulated tempering and magnetizing (STM) Monte Carlo method is a variant of generalized ensemble algorithms that aims at covering a mesh of simulation points in the two-dimensional temperature-field plane in a dynamically controlled manner. We applied STM Monte Carlo simulations to the two-dimensional three-state Potts model in an external magnetic field in order to investigate the crossover scaling behaviour in the temperature-field plane at the Potts critical point and towards the Ising universality class for negative magnetic fields. Our data set has been generated by STM simulations of several square lattices with sizes up to 160×160 spins, supplemented by conventional canonical simulations of larger lattices at selected simulation points. Careful scaling and finite-size scaling analyses of the crossover behaviour with respect to temperature, magnetic field and lattice size will be discussed.

T. Nagai, Y. Okamoto, and W. Janke, J. Stat. Mech.: Theor. Exp. (2013) P02039; Condens. Matter Phys. **16** (2013) 23605.

DY 8.4 Mon 15:45 ZEU 118

Non-equilibrium box overlap in spin glasses — •Markus Manssen[1], Alexander K. Hartmann[1], and A. Peter Young[2] — [1]Carl-von-Ossietzky Universität Oldenburg, Germany — [2]University of California, Santa Cruz, USA

One of the most prominent questions in the theory of spin glasses is the extent to which the mean field solution applies in more realistic situations such as three dimensions. Although not all properties of the mean field solution are reproduced in in three-dimensional systems, numerical simulations indicate that the distribution $P(q)$ of spin overlaps does resemble that in mean field theory, and the same seems to hold for overlaps in small cubic boxes of side length B. Here we have studied box overlaps in the non-equilibrium regime to investigate what changes occur when the range of correlations, initially very small, grows with time and eventually exceeds the box size. We performed long time simulations over 10^8 time steps of the 3D Edwards-Anderson model of size 128^3 with binary couplings by utilizing general purpose GPU programming, which allows us to reach single-spin-flip times of 8ps. We measured the growing correlations and box overlaps. Additionally we simulated smaller systems to see what changes in the box overlaps occur when the whole system equilibrates.

DY 8.5 Mon 16:00 ZEU 118

Self-avoiding walks and Θ-polymers on crititcal percolation clusters — •Niklas Fricke and Wolfhard Janke — Institut für Theoretische Physik and Centre for Theoretical Sciences (NTZ), Universität Leipzig, Postfach 100920, 04009 Leipzig, Germany

Self-avoiding walks (SAWs) on critical percolation clusters are a basic model for polymers in crowded disordered media. The fractal nature of the clusters gives rise to interesting scaling behavior of the SAWs, which is still poorly understood despite considerable efforts in the past. We developed an exact enumeration method which exploits the fractal structure of the critical cluster [1]. The method can handle walks of several thousand steps, amounting to over 10^{1000} conformations. This enables us to determine the SAW scaling exponents on critical percolation clusters with unprecedented accuracy. We also look at self-attracting SAWs, a.k.a. Θ-polymers. Here, the comprehensive information obtained via exact enumeration is particularly valuable as it allows for a close analysis of temperature-driven phase transitions.

[1] N. Fricke and W. Janke, Europhys. Lett. 99, 56005 (2012).

DY 8.6 Mon 16:15 ZEU 118

News and views in discontinuous phase transitions — •Jan Nagler — ETH Zurich

Recent progress in the theory of discontinuous percolation allows us to better understand the the sudden emergence of large-scale connectedness both in complex networked systems and on the lattice. We analytically study mechanisms for the amplification of critical fluctuations at the phase transition point, non-self-averaging and power law fluctuations. 'Single event analysis' allows to establish criteria for discontinuous percolation transitions, even on the high-dimensional lattice. Some applications such as salad bowl percolation, competitive establishment of links in growing networks, crackling noise and inverse fragmentation are discussed.

15 min break

Invited Talk DY 8.7 Mon 16:45 ZEU 118

Self-organized criticality in Hamiltonian spin systems: intriguingly ordinary or ordinarily intriguing? — •Helmut G. Katzgraber — Texas A&M University, USA

Self-organized criticality (SOC) refers to the tendency of dissipative systems to drive themselves into a scale-invariant critical state without any parameter tuning. These phenomena are of crucial importance because fractal objects displaying SOC are found everywhere, e.g., in earthquakes, the meandering of sea coasts, or in galactic clusters. Understanding its origin, however, represents a major unresolved puzzle. Pioneering work in the 1980s provided insights into the possible origins of SOC: The sandpile and forest-fire models are hallmark examples of dynamical systems that exhibit SOC. However, these models feature ad hoc dynamics, without showing how these can be obtained from an underlying Hamiltonian. The possible existence of SOC was also tested in random magnets, such as the random-field Ising model, but in all these, at least one parameter had to be tuned, i.e., no true SOC. The first Hamiltonian model displaying true SOC was the infinite-range mean-field Sherrington-Kirkpatrick spin-glass model. Here, we investigate the conditions required for general disordered magnets to display self-organized criticality. Our results are in disagreement with the traditional lore that self-organized criticality is a property of the mean-field regime of spin glasses. In fact, self-organized criticality is recovered only in the strict limit of a diverging number of neighbors.

In light of these result, the behavior of damage spreading on scale-free networks, as well Coulomb glasses are discussed.

DY 8.8 Mon 17:15 ZEU 118

Dynamic scaling and superdiffusion in a critical binary mixture — Dipanjan Chakraborty[1,2], Siegfried Dietrich[1], and •Felix Höfling[1] — [1]Max Planck Institute for Intelligent Systems, Stuttgart, and Institute for Theoretical Physics IV, Universität Stuttgart, Germany — [2]IISER Mohali, SAS Nagar, India

A binary mixture near its consolute point exhibits critical fluctuations of the local composition. The static properties of the mixture are well described by the 3D Ising universality class [1], the dynamic properties involving conservation of particles, energy, and momentum are classified as *model H′*. So far, theoretical work on the critical dynamics has focused on transport coefficients, while studies of the relaxation dynamics of the spatially resolved order parameter are missing.

We present numerical results for the dynamic structure factor $S(k,t)$ of a symmetric binary Lennard-Jones mixture near its demixing transition. Employing the computing resources of high-end GPUs [2], we have performed microcanonical molecular dynamics simulations which cover system sizes of up to 216,000 particles and 4 non-trivial orders of magnitude in time. We explore the crossover of the k-dependent relaxation time from diffusion-like to critical behaviour and find nice agreement with theoretical predictions. Dynamic scaling of $S(k,t)$ at criticality is tested and scaling functions are deduced. For interdiffusion, we have evidence that the vanishing of the diffusion constant is accompanied by *super*diffusion within intermediate time windows.

[1] S. K. Das *et al.*, J. Chem. Phys. **125**, 024506 (2006)

[2] P. Colberg and F. Höfling, Comp. Phys. Comm. **182**, 1120 (2011)

DY 8.9 Mon 17:30 ZEU 118

Numerical evidence for strong randomness scaling at a superfluid-insulator transition of one dimensional bosons — •Susanne Pielawa[1] and Ehud Altman[1,2] — [1]Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot 76100, Israel — [2]Department of Physics, University of California, Berkeley, California 94720, USA

We present numerical evidence from Monte-Carlo simulations that the superfluid-insulator quantum phase transition of interacting bosons subject to strong disorder in one dimension is controlled by the strong-randomness critical point. At this critical point the distribution of superfluid stiffness over disorder realizations develops a power-law tail reflecting a universal distribution of weak links. The Luttinger parameter on the other hand does not take on a universal value at this critical point, in marked contrast to the known Berezinskii-Kosterlitz-Thouless-like superfluid-insulator transition in weakly disordered systems. We develop a finite-size scaling procedure which allows us to directly compare the numerical results from systems of linear size up to 1024 sites with theoretical predictions obtained in [PRL 93, 150402 (2004)], using a strong disorder renormalization group approach. The data shows good agreement with the scaling expected at the strong-randomness critical point.

DY 8.10 Mon 17:45 ZEU 118

Universal shape functions at classical critical points — •Stephen Inglis[1], Jean-Marie Stèphan[2], Paul Fendley[2], and Roger G. Melko[1,3] — [1]University of Waterloo, Waterloo, Canada — [2]University of Virginia, Charlottesville, USA — [3]Perimeter Institute for Theoretical Physics, Waterloo, Canada

We demonstrate how the Rènyi mutual information (RMI) can be used to characterize universality at the critical point of two dimensional classical systems through their shape dependence, similar to the result of c-theorems in one dimensional systems.

We introduce a highly efficient method for calculating the RMI in discrete classical systems, and use it on the two dimensional Ising and Potts models. This method avoid the difficulty of thermodynamic integration needed in earlier techniques [Phys. Rev. B 87, 195134 (2013)] and allows for direct access to the RMI for different geometries. The method is similar to the quantum ratio trick [Phys. Rev. Lett. 104, 157201 (2010)] except that we gain a large increase in speed and convergence by using classical Monte Carlo. In the cases where classical critical points contain the universality class of interest, this method represents a more efficient approach for extracting universal shape functions.

DY 8.11 Mon 18:00 ZEU 118

Queue with exclusion — •Chikashi Arita[1] and Andreas Schadschneider[2] — [1]Theoretische Physik, Universität des Saarlandes, Saarbrücken, Germany — [2]Institut für Theoretische Physik, Universität zu Köln, Köln, Germany

The history of the queueing theory goes back to A K Erlang 1909. The M/M/1 queueing process is one of basic models in which injection and extraction of particles (customers) are imposed. When pedestrians make a queue, they usually proceed when there is a space in front of them. However this excluded-volume effect is neglected in the M/M/1 queue. The "exclusive queueing process (EQP)" was introduced to take this effect into account by imposing a new boundary condition on the exclusion process [1,2]. The M/M/1 queue converges (diverges) when the incoming rate is smaller (greater) than the outgoing rate, "phase transition". On the other hand, in the EQP, the incoming rate is restricted by the so-called maximal current of the exclusion process for convergence, i.e. "the queue itself is a bottleneck." This property was derived by using an exact stationary state [1,2]. Furthermore, with helps of Monte Carlo Simulations, some time dependent properties of the system length L have been investigated [3,4,5]. Recently an update rule dependent behavior of L was found on the phase transition line [6].

[1] CA: Phys Rev E 80, 051119 (2009) [2] CA & D Yanagisawa: J Stat Phys 141, 829 (2010) [3] CA & AS: Phys Rev E 83, 051128 (2011) [4] CA & AS: Phys Rev E 84, 051127 (2011) [5] CA & AS: J Stat Mech, P12004 (2012) [6] CA & AS: EPL, in press (2013)