DY 11: Critical phenomena

Time: Monday 15:30–18:00 Location: HÜL 186

DY 11.1 Mon 15:30 HÜL 186

Temperatures are not useful to characterise bright-soliton experiments for ultra-cold atoms — •Christoph Weiss[1], Simon Gardiner[1], and Bettina Gertjerenken[2] — [1]Joint Quantum Centre (JQC) Durham-Newcastle, Department of Physics, Durham University, UK — [2]Department of Mathematics and Statistics, University of Massachusetts, Amherst, MA 01003-4515, USA

Contrary to many other translationally invariant one-dimensional models, the low-temperature phase for an attractively interacting one-dimensional Bose-gas (a quantum bright soliton) is stable against thermal fluctuations [1,2]. However, treating the thermal properties of quantum bright solitons within the canonical ensemble leads to anomalous fluctuations of the total energy that indicate that canonical and micro-canonical ensembles are not equivalent. State-of-the-art experiments are best described by the micro-canonical ensemble, within which we predict a co-existence between single atoms and solitons even in the thermodynamic limit - contrary to strong predictions based on both the Landau hypothesis and the canonical ensemble. This questions the use of temperatures to describe state-of-the-art bright soliton experiments that currently load Bose-Einstein condensates into quasi-one-dimensional wave guides without adding contact to a heat bath. [3]

[1] C. Weiss, arXiv:1610.09070

[2] C. Herzog, M. Olshanii, and Y. Castin, Comptes Rendus Physique 15, 285 (2014), arXiv:1311.3857.

[3] C. Weiss, S. A. Gardiner, B. Gertjerenken, arXiv:1610.09074

DY 11.2 Mon 15:45 HÜL 186

Testing conformal invariance in near-critical colloidal suspensions — •Hendrik Hobrecht and Fred Hucht — Fakultät für Physik, Universität Duisburg-Essen, 47048 Duisburg

Both the critical Casimir interaction between two colloids immersed in a critical medium as well as the according interaction between two plates confining such a fluctuating medium are governed by the scaling functions known from conformal field theory. They are two special cases of a vast variety of possible geometries which are all connected via conformal mappings. However, near criticality conformal invariance no longer holds true and the geometry of the system has an effect on the form of the according scaling functions. Assuming that the geometric scaling variable from conformal field theory is nevertheless sufficient in the scaling regime of a near-critical system, we use the exact critical Casimir interaction scaling function of the Ising universality class in cylinder geometry with variable aspect ratio and open boundaries to expand the predictions to colloidal suspensions. Therefore we discuss which length scale is suitable for the temperature scaling variable and compare our results with Monte Carlo studies of two-dimensional systems of colloidal particles with according boundary conditions.

DY 11.3 Mon 16:00 HÜL 186

The square lattice Ising model on the rectangle — •Fred Hucht — Fakultät für Physik, Universität Duisburg-Essen, 47048 Duisburg

The partition function of the square lattice Ising model on the rectangle is calculated exactly for arbitrary system size $L \times M$ and temperature. We start with the dimer method of Kasteleyn, McCoy & Wu, construct a highly symmetric block transfer matrix and derive a factorization of the involved determinant, effectively decomposing the free energy of the system into two parts, $F(L,M) = F_{\text{strip}}(L,M) + F^{\text{res}}_{\text{strip}}(L,M)$, where the residual part $F^{\text{res}}_{\text{strip}}(L,M)$ contains the nontrivial finite-L contributions for fixed M. It is given by the determinant of a $M/2 \times M/2$ matrix and can be mapped onto an effective spin model with M Ising spins and long-range interactions. While $F^{\text{res}}_{\text{strip}}(L,M)$ becomes exponentially small for large L/M or off-critical temperatures, it leads to important finite-size effects such as the critical Casimir force near criticality.

In the finite-size scaling limit, the involved expressions simplify and lead to the scaling functions of the Casimir potential and of the Casimir force. At criticality, a prediction from conformal field theory is confirmed.

Alfred Hucht, "The square lattice Ising model on the rectangle I: Finite systems", J Phys A: Math. Theo., 2016, arXiv:1609.01963, accepted

Alfred Hucht, "The square lattice Ising model on the rectangle II: Finite-size scaling limit", in preparation

DY 11.4 Mon 16:15 HÜL 186

Ensemble dependence of the critical Casimir force — •Markus Gross[1,2], Oleg Vasilyev[1,2], Andrea Gambassi[3], and Siegfried Dietrich[1,2] — [1]Max-Planck-Institut für Intelligente Systeme, Heisenbergstraße 3, 70569 Stuttgart, Germany — [2]IV. Institut für Theoretische Physik, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [3]SISSA – International School for Advanced Studies and INFN, via Bonomea 265, 34136 Trieste, Italy

Confining a near-critical fluid leads to critical Casimir forces acting on the boundaries. Critical Casimir forces have been studied so far in the grand canonical ensemble, in which the confined fluid exchanges particles with the surroundings. However, the canonical ensemble, in which the total number of particles in the confined fluid is fixed, is also relevant in certain circumstances. It is well-known that these ensembles are not equivalent in finite systems. This carries over to the critical Casimir force, which behaves significantly different in the two cases: for instance, for so-called (++) boundary conditions, the canonical force is repulsive instead of attractive and it decays algebraically instead of exponentially upon increasing the temperature scaling variable in the supercritical regime [1]. While these features can be rationalized within mean field theory, additional differences emerge upon accounting for fluctuations. These latter aspects are discussed within a statistical field theory in the canonical ensemble.

[1] M. Gross, O. Vasilyev, A. Gambassi, S. Dietrich, Phys. Rev. E 94, 022103 (2016)

15 min. break

DY 11.5 Mon 16:45 HÜL 186

Dynamical crossovers in prethermal critical states — •Alessio Chiocchetta[1], Andrea Gambassi[2], Sebastian Diehl[1], and Jamir Marino[1] — [1]University of Cologne, Cologne, Germany — [2]International School for Advanced Studies, Trieste, Italy

We study the prethermal dynamics of an interacting field theory with a N-component order parameter and O(N) symmetry, suddenly quenched in the vicinity of a dynamical critical point. Depending on the initial conditions, the evolution of the order parameter, as well as of response and correlation functions, can exhibit a temporal crossover between universal dynamical scaling regimes governed, respectively, by a quantum and a classical prethermal fixed point, as well as a crossover from Gaussian to prethermal dynamical scaling. Together with a recent experiment, this suggests that quenches can be used in order to explore the rich variety of dynamical critical points occurring in the non-equilibrium dynamics of a quantum many-body system. We illustrate this fact by using a combination of functional renormalization group techniques and a non-perturbative large-N limit.

DY 11.6 Mon 17:00 HÜL 186

Integer quantum Hall transitions in random Voronoi-Delaunay lattices — •Martin Puschmann[1,2], Philipp Cain[1], Michael Schreiber[1], and Thomas Vojta[2] — [1]Institute of Physics, Technische Universität Chemnitz, Chemnitz, Germany — [2]Department of Physics, Missouri University of Science and Technology, Rolla, Missouri, USA

The random Voronoi-Delaunay lattice (VDL) is a prototypical model for amorphous solids and foams. Bonds between randomly positioned sites are obtained by Delaunay triangulation. The resulting topologically disordered lattice features strong anticorrelations between the coordination numbers of neighboring sites. This modifies the Harris and Imry-Ma criteria and leads to qualitative changes of the scaling behavior at magnetic phase transitions [1]. We have recently shown that for non-interacting electrons on two-dimensional random VDLs all states are still localized and thus this correlated topological disorder is not sufficient to induce a phase transition [2]. Now, we investigate the behavior in presence of a magnetic field. Landau bands are formed by the field and hence phase transitions occur. Based on a recursive Green function approach and the multifractal analysis, we analyze the critical behavior of the lowest Landau level on random VDLs. [1] Barghathi el al., Phys. Rev. Lett. 113, 120602 (2014); [2] Puschmann et al., Eur.

Phys. J. B 88, 314 (2015)

DY 11.7 Mon 17:15 HÜL 186

Understanding population Monte Carlo simulations — •Martin Weigel[1], Lev Yu. Barash[2,3], Lev N. Shchur[2,3,4], and Wolfhard Janke[5] — [1]Applied Mathematics Research Centre, Coventry University, Coventry, CV1 5FB, England — [2]Landau Institute for Theoretical Physics, 142432 Chernogolovka, Russia — [3]Science Center in Chenogolovka,142432 Chernogolovka, Russia — [4]National Research University Higher School of Economics, 101000 Moscow, Russia — [5]Institut für Theoretische Physik, Universität Leipzig, Postfach 100920 04009, Leipzig, Germany

Population annealing is a sequential Monte Carlo scheme that is potentially able to make use of highly parallel computational resources. Additionally, it promises to allow for the accelerated simulation of systems with complex free-energy landscapes, much alike to the much more well known replica-exchange or parallel tempering approach. The relative performance with respect to such more traditional techniques, the appropriate choice of population sizes temperature protocols and other parameters, the estimation of statistical and systematic errors and many other features, however, are essentially uncharted territory. Here, we use a systematic comparison of population annealing to Metropolis as well as parallel tempering simulations for the Ising model to gauge the potential of this new approach, and we suggest a range of heuristics for its application in more general circumstances.

DY 11.8 Mon 17:30 HÜL 186

Scaling theory of the Anderson transition in random graphs: ergodicity and universality — •Remy Dubertrand[1], Ignacio Garcia-Mata[2], Olivier Giraud[3], Bertrand Georgeot[4], John Martin[1], and Gabriel Lemarie[4] — [1]IPNAS CESAM Université de Liège, Liège, Belgium — [2]IFIMAR CONICET-UNMdP, Mar del Plata, Argentina — [3]LPTMS CNRS Université Paris-Sud, Orsay, France — [4]LPT IRSAMC Université de Toulouse CNRS, Toulouse, France

We study the Anderson transition on a generic model of random graphs with a tunable branching parameter $1 < K \leq 2$, through large scale numerical simulations and finite-size scaling analysis. This problem has attracted a renewed attractivity and is currently hotly debated [1,2,3].

We find that a single transition separates a localized phase from an unusual delocalized phase which is ergodic at large scales but strongly non-ergodic at smaller scales. The critical scalings and exponents are independent of the branching parameter, which strongly supports the universality of our results. During the talk I will describe the results presented in [4] and stress the unusual features of the Anderson transition we find on these random graphs.

[1] B. Altshuler et al., arXiv:1605.02295 (2016)
[2] K. Tikhonov et al., arXiv:1604.05353 (2016)
[3] D. Facoetti et al., arXiv:1607.05942 (2016)
[4] I. Garcia-Mata et al., arXiv:1609.05857 (2016)

DY 11.9 Mon 17:45 HÜL 186

Approximate ground states of the random-field Potts model from graph cuts and parallel tempering — Manoj Kumar[1], •Ravinder Kumar[2,3], Varsha Banerjee[4], Sanjay Puri[1], Martin Weigel[2], and Wolfhard Janke[3] — [1]School of Physical Sciences, Jawaharlal Nehru University,New Delhi-110067, India — [2]Applied Mathematics Research Centre, Coventry University, Coventry, UK. — [3]Institut für Theoretische Physik, Leipzig University, Leipzig, Germany. — [4]Department of Physics, Indian Institute of Technology, Hauz Khas, New Delhi - 110016, India.

While the ground-state problem for the random-field Ising model is polynomial, and can be solved using a number of well known algorithms for maximum flow, the analogue random-field Potts model corresponds to a multi-terminal flow problem that is known to be NP hard. Hence an efficient exact algorithm is extremely unlikely to exist. Still, it is possible to employ embedding of binary degrees of freedom into the Potts spins to use graph-cut methods to solve the corresponding ground-state problem approximately with polynomial methods. It is shown here that this works relatively well. We compare results produced by this heuristic algorithm to energy minima found by an appropriately tuned parallel tempering method that is configured to find ground states for the considered system sizes with high probability. The method based on graph cuts finds the same states in a fraction of the time. The new method is used for a first exploratory study of the random-field Potts model in two dimensions.