DY 10: Statistical Physics I (General)

Time: Monday 10:00–12:45 Location: BH-N 333

DY 10.1 Mon 10:00 BH-N 333

Scaling behavior of self-avoiding walks on critical percolation clusters in two to seven dimensions from exact enumeration — •Wolfhard Janke and Niklas Fricke — Institut für Theoretische Physik, Universität Leipzig, Postfach 100 920, 04009 Leipzig, Germany

We study the scaling behavior of self-avoiding walks on critical percolation clusters by means of a recently developed exact enumeration method, which can handle walks of several thousand steps. We had previously presented results for the two- and three-dimensional cases; here we take a wider perspective and vary the system's dimensions up to $D = 7$, beyond the supposed upper critical dimension of $D_{\mathrm{uc}} = 6$. These results may serve as a check of analytical predictions and help understand how the medium's fractal structure impacts on the walks' scaling behavior. For the physically relevant, smaller dimensions, the scaling exponent ν for the end-to-end distance turns out to be smaller than previously thought and appears to be the same on the backbones as on full clusters. For the number of conformations, the "partition function", we find strong evidence against the widely assumed scaling law and propose an alternative, which perfectly fits our data.

[1] N. Fricke and W. Janke, Phys. Rev. Lett. **113**, 255701 (2014).
[2] N. Fricke and W. Janke, J. Phys. A **50**, 264002 (2017).

DY 10.2 Mon 10:15 BH-N 333

High precision free energy-distribution of directed polymers in random media — •Alexander K. Hartmann[1], Pierre Le Doussal[2], Satya N. Majumdar[3], Alberto Rosso[3], and Gregory Schehr[3] — [1]Institut für Physik, Universität Oldenburg, Germany — [2]LPT, Ecole Normale Supérieure, Paris, France — [3]LPTMS, Université Paris Sud, France

We study the distribution of relative free energies H of directed polymers in disordered media coupled to a heat bath at temperature T, which is in the Kardar-Parisi-Zhang (KPZ) universality class in $1+1$ dimensions. We study the distribution at large and medium small temperatures, corresponding to short and medium long times in KPZ. Using a statistical mechanics-based large-deviation approach [1], the distribution can be obtained over a large range of the support, down to a probability density as small as 10^{-1000}. We compare with analytical predictions for the KPZ equation for short [2] and long times [3], respectively. For short times a very good agreement is found for $H < 0$ and a convergence is visible for $H > 0$. For large times, an asymptotic convergence in the tails is visible.

[1] A.K. Hartmann, Phys. Rev. E **65**, 056102 (2002).
[2] P. Le Doussal, S.N. Majumdar, A. Rosso, and G. Schehr, Phys. Rev. Lett. **117**, 070403 (2016).
[3] P. Sasorov, B. Meerson, and S. Prolhac, J. Stat. Mech. 2017, 063203 (2017).

DY 10.3 Mon 10:30 BH-N 333

Optimal packing of confined dipolar hard spheres — •Florian Deissenbeck[1], Hartmut Löwen[1], and Erdal Celal Oguz[2] — [1]HHU Düsseldorf, Institut für Theoretische Physik 2: Weiche Materie — [2]Tel Aviv University, School of Mechanical Engineering and The Sackler Center for Computational Molecular and Materials Science

We investigate the ground state of a classical two-dimensional system of hard-sphere dipoles confined between two hard walls. Using lattice sum minimization techniques we reveal that at fixed wall separations, a first-order transition from a vacuum to a straight one-dimensional chain of dipoles occurs upon increasing the line density. A further increase in this density yields the stability of an undulated chain with a nontrivial magnetic dipolar structure. By exploring the close-packed configurations of dipoles, which in general possess complex magnetizations, we find a novel phase structure that has a higher packing fraction than hitherto known ones. Our predictions serve as a guideline for experiments with granular dipolar and magnetic colloidal suspensions confined in slit-like geometry.

DY 10.4 Mon 10:45 BH-N 333

A new perspective on laser-induced freezing and reentrant melting — •Alexander Kraft and Sabine H. L. Klapp — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin

Laser-induced freezing (LIF) of a two-dimensional colloidal system describes the phenomenon in which a one-dimensional interfering laser beam pattern can induce a liquid-crystal freezing transition [1]. In this contribution, we propose a new perspective of the microscopic origin of LIF. Using free minimization techniques within density functional theory for a model system subjected to two different substrate potentials, we show that there is strong evidence that the increase of the light intensity is not the only reason for the occurrence of LIF, but its accompanying side-effect to increase the effective average density. In our approach, we characterize the inhomogeneous density distribution of particles in terms of two quantities: We introduce a confining length L_c to characterize the region within which a representative fraction of particles are confined and the effective average density $\bar{\rho}_{eff}$ within this region. In this way, our approach allows to make theoretical predictions for the critical value of the light intensity for the onset of LIF and allows to define a quantitative measure for the reduced registration introduced by [2] to understand reentrant melting.

[1] A. Chowdhury et al., Phys. Rev. Lett. **55**, 833 (1985)
[2] Q. H. Wei et al., Phys. Rev. Lett. **81**, 2606 (1998)
[3] L. Radzihovsky et al. Phys. Rev. E **63**, 031503 (2001)

DY 10.5 Mon 11:00 BH-N 333

Duality between relaxation and first passage in reversible Markov dynamics — •David Hartich and Aljaz Godec — Mathematical Biophysics Group, Max-Planck-Institute for Biophysical Chemistry (Göttingen)

The first passage time characterizes the time until a stochastic process reaches a given threshold for the first time, e.g. the first instance a molecule reaches its target, or the first crossing of an energetic barrier. Complementary to first passage time statistics are well known relaxation processes. Until now an explicit connection between a first passage process and a relaxation process, albeit sought for, remained elusive.

Here, we prove a duality between them in the form of a spectral interlacing enabling us to explicitly determine the full first passage time distribution in terms of a simple relaxation process. To illustrate our theory we analyze diffusion in a triple-well potential, and express the first passage time statistics in terms of relaxation eigenmodes. Finally, we highlight the relevance of our theory by studying first passage kinetics in the so-called few-encounter limit dominated by the fastest reactive trajectories. Our results are relevant for gene regulation processes and the triggering of certain neurodegenerative diseases.

15 min. break

DY 10.6 Mon 11:30 BH-N 333

Linear Programming and Cutting Planes for Ground States and Excited States of the Traveling Salesperson Problem — •Hendrik Schawe[1], Jitesh Jha[2], and Alexander K. Hartmann[1] — [1]Institut für Physik, Carl von Ossietzky Universität Oldenburg — [2]Manipal Institute of Technology

The Traveling Salesperson problem asks for the shortest cyclic tour visiting a set of cities given their pairwise distances and belongs to the NP-hard complexity class, which means that all NP problems, like spin glass groundstate, can be mapped to it.

We look at excited states to explore the energy landscape in detail. The linear programming approach offers capable tools to find excited states fulfilling very specific requirements. This allows us, e.g., to find the second shortest tour or the tour most different to the optimal tour within some allowed excitation ϵ, e.g., 1% longer than the optimum. We are especially interested whether the energy landscape is complex, i.e., shows signatures of replica symmetry breaking in analogy to spin glasses.

DY 10.7 Mon 11:45 BH-N 333

Langevin equations for reaction-diffusion processes — Federico Benitez[1,2], •Charlie Duclut[3], Hugues Chaté[4,5,3], Bertrand Delamotte[3], Ivan Dornic[4,3], and Miguel A. Muñoz[6] — [1]Max Planck Institute for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany — [2]Physikalisches Institut, Universität Bern, Sidlerstr. 5, 3012 Bern, Switzerland — [3]Laboratoire de Physique Théorique de la Matière Condensée, CNRS UMR7600, UPMC-Sorbonne Universités, 75252 Paris Cedex 05, France — [4]Service de

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For reaction-diffusion processes with at most bimolecular reactants, we derive well-behaved, numerically-tractable, exact Langevin equations that govern a stochastic variable related to the response field in field theory. Using *duality* relations, we show how the particle number and other quantities of interest can be computed. Our work clarifies long-standing conceptual issues encountered in field theoretical approaches and paves the way to systematic numerical and theoretical analyses of reaction-diffusion problems.

DY 10.8 Mon 12:00 BH-N 333

Random distributions: what doping densities enable entangling gates to be formed in silicon? — •Eleanor Crane[1], Andrew Fisher[1], Thomas Crane[2,3], Ben Murdin[4], and Neil Curson[1] — [1]London Centre for Nanotechnology, University College London, London WC1H 0AH, UK — [2]ENS Paris, 45 Rue d'Ulm, 75005 Paris, France — [3]Université Sorbonne Paris Cité, Université Paris Diderot - Paris VII, 5 Rue Thomas Mann, 75013 Paris, France — [4]Advanced Technology Institute, University of Surrey, Guildford, GU2 7XH, United Kingdom

Entangling the quantum states of impurity atoms in condensed matter is a crucial step towards the creation of a solid state quantum computer. In a whole range of experiments aiming at this, atoms need to be spaced by specific spatial distances. This is also the case in the Stoneham Fisher Greenland scheme [1] for which we determine the density of entangling gates in a randomly doped multi-species silicon sample. We use Poisson point processes, for which we also show a number of properties, and verify our results using a Monte Carlo simulation. These methods are of general interest for Poisson point processes and the fields which use them as models of random physical phenomena.

[1] Stoneham A M, Fisher A J and Greenland P T, 2003, J. Phys.: Condens. Matter 15 L447*L451

DY 10.9 Mon 12:15 BH-N 333

Expanding the effective action around non-Gaussian theories — •Tobias Kühn[1] and Moritz Helias[1,2] — [1]Inst. of Neurosc. and Medicine (INM-6), Inst. for Advanced Simulation (IAS-6) and JARA BRAIN Inst. I, Jülich Research Centre, Germany — [2]Department of Physics, Faculty 1, RWTH Aachen University, Aachen, Germany

The effective action or Gibbs Free Energy is the central quantity to study phase transitions and is at the core of effective theories constructed, for example, by the renormalization group. It is known that only one-line-irreducible Feynman diagrams contribute in the case that the theory, about which one expands, is Gaussian. We introduce a generalized notion of one-line-irreducibility: diagrams that remain connected after detaching a single leg of an interaction vertex. We show that the effective action decomposes into diagrams that are either irreducible in this more general sense or belong to a second class of diagrams that has no analogue in Gaussian theories [Kühn & Helias 2017, arXiv:1711.05599]. The presented method allows the efficient diagrammatic perturbative computation of the effective action around any exactly solvable problem. We illustrate this method by application to the (classical) Ising model expanded in the coupling strength. This reproduces the Plefka expansion [Plefka 1982], including the TAP-correction [Thouless et al. 1977] to mean-field theory. We find that the diagrammatic formulation considerably simplifies the calculation compared to existing techniques [Takayama & Nakanishi 1997, Georges & Yedidia 1991]. Supported by the Helmholtz foundation (VH-NG-1028, SMHB); EU Grant 604102 (HBP).

DY 10.10 Mon 12:30 BH-N 333

Scaling of density fluctuations and hyperuniformity in one-dimensional substitution tilings — •Erdal C. Oğuz[1,4], Joshua E. S. Socolar[2], Paul J. Steinhardt[3], and Salvatore Torquato[4] — [1]School of Mechanical Engineering and The Sackler Center for Computational Molecular and Materials Science, Tel Aviv University, Tel Aviv 6997801, Israel — [2]Department of Physics, Duke University, Durham, NC 27708 — [3]Princeton Center for Theoretical Science and Department of Physics, Princeton University, Princeton, NJ 08544 — [4]Department of Chemistry, Princeton University, Princeton, 08540

Substitution tilings include periodic, quasiperiodic, limit periodic, and other self-similar structures generated by iterated subdivision and rescaling of a finite set of tiles. We study the scaling of density fluctuations associated with a broad class of substitution rules in one dimension. We show that a simple, heuristic argument for the rate of decay of the integrated Fourier intensity $Z(k)$ at small values of the wavenumber k correctly predicts the scaling of the variance $\sigma^2(R)$ in the number of points contained in intervals of length $2R$. The exponent α, defined by $Z \sim k^{\alpha+1}$, is determined by the ratio of the second largest and largest eigenvalues of the substitution matrix and can vary between -1 and 3, where $\alpha > 0$ implies a hyperuniform distribution of tile vertices. The hyperuniform class includes tilings that are periodic, quasiperiodic, or limit periodic, including a new class of limit-periodic tilings for which Z approaches zero faster than any power law. Tilings with singular continuous diffraction spectra may be hyperuniform or may exhibit stronger fluctuations than a Poisson system.