DY 12: Statistical physics (general)

Time: Tuesday 10:00–12:00 Location: H3

DY 12.1 Tue 10:00 H3

Energy correlations for a random matrix model of disordered bosons — •Tobias Lück[1], Hans-Jürgen Sommers[2], and Martin Zirnbauer[1] — [1]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Campus Essen, 45117 Essen, Germany

Linearizing the equations of motion around the ground state of an interacting quantum many-body system, one gets a time-evolution generator in the positive cone of a real symplectic Lie algebra. The presence of disorder in the physical system determines a probability measure with support on this cone. We analyzed a discrete family of such measures of exponential type using a simple random matrix model. Some generic statistical features of the characteristic frequencies of disordered bosonic quasi-particle systems can be derived. The level correlation functions of the said measures are shown to be those of a determinantal process, and the kernel of the process is expressed as a sum of bi-orthogonal polynomials. While the correlations in the bulk scaling limit are in accord with sine-kernel or GUE universality, at the low-frequency end of the spectrum an unusual type of scaling behavior is found.

DY 12.2 Tue 10:15 H3

Haar measures, relative entropy and the relativistic canonical velocity distribution — •Jörn Dunkel, Peter Talkner, and Peter Hänggi — Institut für Physik, Universität Augsburg, Theoretische Physik I, Universitätsstrasse 1, D-86135 Augsburg, Germany

The concept of equipartition (uniform distribution) can be extended to locally compact, topological groups by means of the Haar measure. Guided by this fact, we propose that the relative entropy with respect to the Haar measure of the Lorentz group provides the most natural choice for the canonical equilibrium entropy in relativistic thermostatistics. Maximization of this entropy under the usual constraints yields a modified one-particle Jüttner distribution that differs from the standard Jüttner distribution by a prefactor which is proportional to the inverse relativistic kinetic energy. The argument shows that only the modified distribution is consistent with the principle of Lorentz invariance, whereas the standard Jüttner function is not. The relevance of this result with regard to applications in high energy physics and astrophysics is discussed.

DY 12.3 Tue 10:30 H3

Nonanalyticities of entropy functions of finite and infinite systems — •Michael Kastner — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth

In contrast to the canonical ensemble where thermodynamic functions are smooth for all finite system sizes, the microcanonical entropy can show nonanalytic points also for finite systems, even if the Hamiltonian is smooth. The relation between finite and infinite system nonanalyticities is illustrated by means of a simple classical spin-like model which is exactly solvable for both, finite and infinite system sizes, showing a phase transition in the latter case. The microcanonical entropy is found to have exactly one nonanalytic point in the interior of its domain. For all finite system sizes, this point is located at the same fixed energy value $\varepsilon_c^{\text{finite}}$, jumping discontinuously to a different value $\varepsilon_c^{\text{infinite}}$ in the thermodynamic limit. Remarkably, $\varepsilon_c^{\text{finite}}$ equals the average *potential* energy of the infinite system at the phase transition point. The result, supplemented with results on nonanalyticities of the microcanonical entropy for other models, indicates that care is required when trying to infer infinite system properties from finite system nonanalyticities.

DY 12.4 Tue 10:45 H3

The density of states in complex systems: the case of RNA secondary structures — •Stefan Wolfsheimer, Bernd Burghardt, and Alexander Hartmann — Institut für theoretische Physik, Friedrich-Hund-Platz 1, 37077 Göttingen

Models for RNA secondary structures (the topology of folded RNA) without pseudo knots have interesting properties: On one side they are complex systems with an ultrametric-like state-space structure, leading to high entropic barriers. Due to this fact Monte Carlo methods to obtain ground-state properties (energy, degeneracy etc.) and density of states become stuck very quickly. On the other side, in contrast to many complex systems, the ground states and the density of states can by computed in polynomial time exactly. Hence, RNA secondary structures provide an ideal benchmark system for new Monte Carlo methods. Recently the ParQ algorithm, a transition matrix approach, was introduced by Heilmann et.al. (Euro.Phys.Lett.**70(2)**: 155-161,2005) In this study we investigate the impact of the ParQ annealing schedule on the performance of the algorithm. We als characterize the ground-state structure using the overlap distribution and the degree of ultrametricity, which turns out to be directly related to tunneling times and performance of the algorithm.

DY 12.5 Tue 11:00 H3

Fluctuations in subsystems of the zero temperature XX chain: emergence of an effective temperature — •Viktor Eisler[1], Örs Legeza[2], and Zoltan Racz[3] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany — [2]Research Institute for Solid State Physics and Optics, H-1525 Budapest, P.O. Box 49, Hungary — [3]Institute for Theoretical Physics, Eötvös University, 1117 Budapest, Pazmany setany 1/a, Hungary

The zero-temperature XX chain is studied with emphasis on the properties of a block of spins inside the chain. We investigate the quantum fluctuations resulting from the entanglement of the block with the rest of the chain using analytical as well as numerical (density matrix renormalization group) methods. It is found that the rest of the chain acts as a thermal environment and an effective temperature can be introduced to describe the fluctuations. We show that the effective temperature description is robust in the sense that several independent definitions (through fluctuation dissipation theorem, comparing with a finite temperature system) yield the same functional form in the limit of large block size. The effective temperature can also be shown to satisfy the basic requirements on how it changes when two bodies of equal or unequal temperatures are brought into contact.

DY 12.6 Tue 11:15 H3

Optimization of packing problems — •Johannes Josef Schneider, Gösta Kroll, Pavel Metelitsyn, Philipp Roos, and Elmar Schömer — Department of Physics, Mathematics, and Computer Science, Johannes Gutenberg University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany

Packing many homogeneous or heterogeneous objects is a challenging mathematical task with many applications in physics and logistics, ranging from the field of soft and granular matter to the question how to pack suitcases and some bulky goods in a rear trunk.

We use both global methods like Simulated Annealing [1,2] and local methods for the optimization of packing problems. In a first attempt, we studied the packing of discs with various radii within a circle of minimum radius and took part in an international competition, in which we were able to set the world record for one benchmark instance.

[1] S. Kirkpatrick, C. D. Gelatt Jr., and M. P. Vecchi, Science **220**, 671, 1983.

[2] J. J. Schneider and S. Kirkpatrick, *Stochastic Optimization*, Springer, Berlin, Heidelberg, 2006.

DY 12.7 Tue 11:30 H3

Force dependence of transition rates in atomic friction — •Mykhaylo Evstigneev[1], Andre Schirmeisen[2], Lars Jansen[2], Harald Fuchs[2], and Peter Reimann[1] — [1]Universität Bielefeld, Fakultät für Physik, Universitätstr. 25, 33615, Bielefeld — [2]Universität Münster, Center for Nanotechnology, Heisenbergstr. 11, 48149, Münster

The lateral forces during stick-slip motion of an atomic force microscope cantilever on highly oriented pyrolytic graphite are measured and analyzed. We identify the regimes where thermally activated interstitial hopping of the cantilever tip proceeds according to a single-step reaction scheme and extract the corresponding force-dependent transition rates directly from the experimental data. We find that such a single-step reaction scenario is valid only at relatively high velocities, while at slower pulling speeds a more complicated hopping mechanism must be at work. We suggest formation of multiple bonds of the tip-sample contact as a possible candidate for this mechanism.

DY 12.8 Tue 11:45 H3

Football fever: goal distributions in football — •Andreas

Nussbaumer[1], Elmar Bittner[1], Wolfhard Janke[1], and Martin Weigel[2] — [1]Institut für Theoretische Physik, Universität Leipzig, Postfach 100 920, 04009 Leipzig, Germany — [2]Department of Mathematics, Heriot-Watt University, Riccarton, Edinburgh, EH14 4AS, Scotland, UK

Analyzing football score data with statistical techniques, we investigate how the highly co-operative nature of the game is reflected in averaged properties such as the distributions of scored goals for the home and away teams. It turns out that in particular the tails of the distributions are *not* well described by independent Bernoulli trials, but rather well modeled by negative binomial or generalized extreme value distributions. To understand this behavior from first principles, we suggest to modify the Bernoulli random process to include a simple component of *self-affirmation* which seems to describe the data surprisingly well and allows to interpret the observed deviation from Gaussian statistics. The phenomenological distributions used before can be understood as special cases within this framework. We analyzed historical football score data from many leagues in Europe as well as from international tournaments and found the proposed models to be applicable rather universally. In particular, here we compare men's and women's leagues and the separate German leagues during the cold war times and find some remarkable differences.