DY 3: Statistical Physics far from Thermal Equilibrium - Part I

Time: Monday 9:30–11:45 Location: ZEU 160

DY 3.1 Mon 9:30 ZEU 160

High-precision work distributions for extreme non-equilibrium processes in large systems — •Alexander K. Hartmann — Institut of Physics, University of Oldenburg, Germany

The distributions of work for strongly non-equilibrium processes are studied using a very general form of a large-deviation approach, which allows one to study distributions down to extremely small probabilities of almost arbitrary quantities of interest for equilibrium, non-equilibrium stationary and even non-stationary processes. The method is applied to varying quickly the external field in a wide range $B = 3 \leftrightarrow 0$ for critical ($T = 2.269$) two-dimensional Ising system of size $L \times L = 128 \times 128$. To obtain free energy differences from the work distributions, they must be studied in ranges where the probabilities are as small as 10^{-240}, which is not possible using direct simulation approaches. By comparison with the exact free energies, one sees that the present approach allows one to obtain the free energy with a very high relative precision of 10^{-4}. This works well also for non-zero field, i.e., for a case where standard umbrella-sampling methods seem to be not so efficient to calculate free energies. Furthermore, for the present case it is verified that the resulting distributions of work fulfill Crooks theorem with high precision. Finally, the free energy for the Ising magnet as a function of the field strength is obtained.

DY 3.2 Mon 9:45 ZEU 160

Unifying three perspectives on information processing in stochastic thermodynamics — •Andre C Barato and Udo Seifert — II. Institut für Theoretische Physik, Universität Stuttgart, Stuttgart 70550

The relation between information and thermodynamics may be studied using three different approaches: (i) measurement and control, (ii) a tape interacting with a system or (iii) by identifying an implicit Maxwell demon in steady state transport. For a single paradigmatic model we derive the three corresponding second laws from one master fluctuation theorem and discuss their relationship. In particular, we show that both the entropy production involving mutual information between system and controller and the one involving a Shannon entropy difference of an information reservoir like a tape carry an extra term different from the usual current times affinity. Moreover, comparing the usual entropy production from stochastic thermodynamics with the one obtained in approach (ii), we show that the former includes the thermodynamic cost of resetting the tape. Finally, inspired by the discussion on the paradigmatic model we generalize stochastic thermodynamics to the presence of an information reservoir.

Reference: arXiv:1308.4598 (2013)

DY 3.3 Mon 10:00 ZEU 160

Bayesian prior-predictive value for multi-modal distributions: thermodynamic integration, or fast-growth? — •Alberto Favaro, Elena Barykina, Daniel Nickelsen, and Andreas Engel — Institut für Physik, Carl-von-Ossietzky Universität, 26111 Oldenburg, Germany

In Bayesian inference, the prior-predictive value allows one to select the model, among different candidates, that fits the data best [Lartillot and Philippe, Syst. Biol. 55, 195-207 (2006)]. A common difficulty, when analysing data through Bayesian methods, is the evaluation of high-dimensional integrals. Techniques that originated in statistical physics, such as thermodynamic integration and fast-growth methods, can be used to mitigate this problem.

Naively, if the distribution of data is multi-modal, one expects that fast-growth algorithms, inspired by the Jarzynski equation, outperform thermodynamic integration. In fact, this last technique does not reliably sample all modes, as it often gets trapped around a maximum. The results of Ahlers and Engel for a bimodal Gaussian distribution appear to confirm this [Eur. Phys. J. B62, 357-364 (2008)]. Nevertheless, the estimate of the prior-predictive value, as obtained from a Jarzynski-like equation, is severely biased. By means of a careful error analysis, we determine the conditions under which a given method is to be preferred. Moreover, it is observed that fast-growth simulations are particularly efficient when computing averages with respect to the posterior distribution.

DY 3.4 Mon 10:15 ZEU 160

Extensions to Endoreversible Modelling — •Katharina Wagner and Karl Heinz Hoffmann — Technische Universität Chemnitz

In endoreversible thermodynamics irreversible processes and systems are split into reversible subsystems and interactions in between them. The irreversibilities are completely described by the interactions between the reversible subsystems. Interactions consist of two fluxes, i. e. energy and an extensive quantity, and are characterized by transport laws.

The standard formalism [1] is extended to model mass fluxes with more than one extensive quantity as carrier for the energy, since the different extensive quantities are usually not independent and need to be treated together. Irreversible systems with gases, like pressure regulators or throttles, are presented to demonstrate endoreversible modelling and quantification of entropy production in the model.

[1] Hoffmann, K. H., Burzler, J. M. and Schubert, S., J. Non-Equilib. Thermodyn. Vol. 22, 1997, No. 4

DY 3.5 Mon 10:30 ZEU 160

Emerging Smectic Phases in Simple Active Particle Models — •Pawel Romanczuk[1], Sandrine Ngo[2], and Hugues Chate[3] — [1]Physikalisch-Technische Bundesanstalt, Berlin, Germany — [2]Dept. of Physics, IPAM and ICSMB, University of Aberdeen, United Kingdom — [3]CEA-Saclay, Service de Physique de l'Etat Condensé, CEA-Saclay, Giv-sur-Yvette, France

Recently, several theoretical predictions have been made on so-called active smectics based on hydrodynamic theories derived solemnly from symmetry arguments [1,2]. Here, we show how the mere addition of pairwise repulsive interaction to alignment-only, self-propelled particle models generically gives rise to active smectic phases, which we study numerically in two space dimensions. The versatility of our approach allows us to study polar as well as apolar smectics of various types (A, C, and a new smectic P phase where particles form files so that the orientational order of the particles is parallel to the smectic stripes). We find that smectic order is rather weak: it is quasi-long-range up to some model-dependent size, but quickly breaks down in larger systems due to the spontaneous nucleation of dislocations and the presence of a long-wavelength undulation instability. Furthermore, our study also reveals a number of unexpected collective dynamical properties such as spontaneous global rotation of both orientational and smectic order.

[1] Adhyapak, T. et al, Phys Rev Lett 110, 11, 118102 (2013)
[2] Chen, L. and Toner, J., Phys Rev Lett 111, 8, 088701 (2013)

15 min break

DY 3.6 Mon 11:00 ZEU 160

Non-monotonic Density in the Compressible Car Parking Problem — •Johannes Nuebler, Brendan Osberg, and Ulrich Gerland — Arnold-Sommerfeld Center for Theoretical Physics and Center for NanoScience, Theresienstraße 37, 80333 München

The non-equilibrium dynamics of the one-dimensional adsorption-desorption process, the so-called "car parking problem", have been extensively studied. For fast adsorption, starting from an empty line, the covered fraction quickly reaches a plateau at which point all "parking spots" are too short for further adsorption. Thereafter, equilibrium is approached through much slower collective rearrangements.

Motivated by histone proteins on DNA, we generalize the adsorption-desorption process to soft particles. In this "compressible car parking problem", the particle density increases much faster and can be non-monotonic. We attribute this to the history of the parking spot size distribution and study its non-equilibrium thermodynamics.

DY 3.7 Mon 11:15 ZEU 160

Uncovering wind turbine properties through two-dimensional stochastic modeling of wind dynamics — Frank Raischel[1], •Teresa Scholz[2,3], Vitor V. Lopes[4], and Pedro G. Lind[5] — [1]Instituto Dom Luiz, CGUL, 1749-016 University of Lisbon, Lisbon, Portugal — [2]Center for Theoretical and Computational Physics, University of Lisbon, Av. Prof. Gama Pinto 2, 1649-003 Lisbon, Portugal — [3]Departamento de Física, Faculdade de Ciências da Universidade de Lisboa, 1649-003 Lisboa, Portugal — [4]Energy Systems Modeling and Optimization Unit, National Laboratory for Energy and Geology (LNEG), Estrada do Paço do Lumiar 22, 1649-038 Lisbon, Portugal

— [5]ForWind and Institute of Physics, Carl-von-Ossietzky University of Oldenburg, DE-26111 Oldenburg, Germany

Using a method for stochastic data analysis, borrowed from statistical physics, we analyze synthetic data from a Markov chain model that reproduces measurements of wind speed and power production in a wind park in Portugal. We first show that our analysis retrieves indeed the power performance curve, which yields the relationship between wind speed and power production and we discuss how this procedure can be extended for extracting unknown functional relationships between pairs of physical variables in general. Second, we show how specific features, such as the rated speed of the wind turbine or the descriptive wind speed statistics, can be related with the equations describing the evolution of power production and wind speed at single wind turbines.

DY 3.8 Mon 11:30 ZEU 160

Noise-insensitive energy transmission with magnetic coupling

— •Benedikt Sabass — Princeton University

Systems with a magnetic coupling display unusual transport properties since time-reversal symmetry is broken. I study energy transmission in coupled oscillators, as it could be realized, e.g., with electronic circuits. Remarkably, magnetic coupling can render energy transmission in certain networks insensitive to perturbations from the outside. The mechanism and conditions for this passive noise compensation are discussed. I conclude with the idea for an application.