DY 18: Statistical Physics Far from Thermal Equilibrium

Time: Wednesday 9:30–12:30 Location: H48

DY 18.1 Wed 9:30 H48

Hardwiring a Maxwell Demon — •Philipp Strasberg[1], Gernot Schaller[1], Tobias Brandes[1], and Massimiliano Esposito[2] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, D-10623 Berlin, Germany — [2]Complex Systems and Statistical Mechanics, University of Luxembourg, L-1511 Luxembourg, Luxembourg

We present a physical implementation of a Maxwell demon which consists of a conventional single electron transistor (SET) capacitively coupled to another quantum dot detecting its state. Altogether, the system is described by stochastic thermodynamics. We identify the regime where the energetics of the SET is not affected by the detection, and where its coarse-grained entropy production is shown to contain a new contribution compared to an isolated SET. This additional contribution can be identified as the information flow generated by the "Maxwell demon" feedback in an idealized limit.

DY 18.2 Wed 9:45 H48

Quantum efficiency of heat engines coupled to nonequilibrium reservoirs — •Obinna Abah[1,2] and Eric Lutz[1,2] — [1]Department of Physics, University of Augsburg, D-86135 Augsburg, Germany — [2]Dahlem Center for Complex Quantum Systems, Freie Universit\"at Berlin, Arnimallee 14, D-14195 Berlin, Germany

We derive the efficiency of quantum heat engines coupled to stationary nonequilibrium reservoirs. We discuss the condition under which the quantum efficiency exceeds its classical limit.

DY 18.3 Wed 10:00 H48

Accumulation and replication of biomolecules driven by the flux of heat — •Moritz Kreysing, Christof Mast, Simon Lanzmich, Lorenz Keil, and Dieter Braun — Systems Biophysics, Department of Physics, LMU München

Central to most Origin-of-Life scenarios is the possibility for pre-biotic organic molecules to form increasingly complex, catalytic machinery, ultimately capable of autonomous replication. While strong evidence for the spontaneous generation of single nucleotides [1] recently arose, concentrations required to allow these building blocks to polymerize [2] to gain functionality still seem improbable for early earth conditions.

Here we demonstrate experimentally that temperature gradients across vertical pores, as they occur in submarine hydrothermal vents [3], are sufficient to accumulate oligonucleotides against high entropic costs. In particular we show that, depending on the pores' dimensions, this thermo-gravitation trapping is strongest for long oligonucleotides and thus provides a length selective molecular filter.

We suggest that equivalent systems could have served as meeting point for long and complex molecules, too rare to find each other in a dilute primordial ocean. Furthermore, we discuss under which conditions length sensitivity could trigger the evolutionary selection of molecular replicators driven by convective thermo-cycling [4].

References: 1. M. Powner et al., Nature 459:239 (2009), 2. G. Costanzo et al., ChemBioChem 13:999 (2012), 3. P. Baaske et al., PNAS 104:9346 (2007), 4. C. Mast and D. Braun, PRL, 104:188102 (2010).

DY 18.4 Wed 10:15 H48

Dynamics of wet granular matter — •Marco Mazza — Max Planck Institute for Dynamics and Self-Organization, Dynamics of Complex Fluids - Bunsen Str. 10, Göttingen, Germany

We present results from computer simulations of the dynamics of wet granular matter. The system exhibits far-from-equilibrium transitions from solid- to fluid-like phase. Differences and analogies to the equilibrium transitions and possible extensions of the equilibrium formalism are discussed.

DY 18.5 Wed 10:30 H48

Random perfect lattices and the sphere packing problem — •Alexei Andreanov[1,2] and Antonello Scardicchio[1,3] — [1]The Abdus Salam ICTP, Trieste, Italy — [2]Max-Planck-Institut fur Physik complexer Systeme, Dresden, Germany — [3]INFN, Sezione di Trieste, Trieste, Italy

We study random sets of perfect lattices in dimensions up to $d = 19$. Perfect lattices are relevant for solution of lattice sphere packing problem. In fact the best lattice packing is a perfect lattice and perfect and eutactic lattices are local maxima of the packing fraction. We use a stochastic generating algorithm for perfect lattices and define a random ensemble with an effective temperature (reminiscent of a Monte Carlo simulation) to study typical properties of perfect lattices and show how as the temperature is decreased the best known packers are easily recovered. We find that the typical perfect lattices are denser than known families and propose two hypotheses for typical packing density between which we cannot distinguish: $\phi \sim 2^{-(0.84\pm0.06)d}$ (improvement of the Minkowksi bound), and a competitor $\phi \sim d^{-ad}$ with a very small coefficient $a = 0.06 \pm 0.04$. We also find properties of the random walk which are suggestive of a glassy system already for moderately small dimensions.

15 min. break.

DY 18.6 Wed 11:00 H48

Globally Coupled Stratonovich Models: Self-consistent Theory of a Non-equilibrium Continuous Phase Transition — •Marc Höll[1] and Ulrich Behn[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany — [2]Institut für Theoretische Physik, Universität Leipzig, Brüderstr. 16, 04103 Leipzig, Germany

We consider a globally harmonically coupled array of N Stratonovich models. The system exhibits a second order non-equilibrium phase transition when crossing a critical value of the control parameter. For strong coupling it is useful to introduce center of mass and relative coordinates since their chararacteristic time scales are clearly separated. We develop a self consistent approximate theory to determine the stationary probability distributions of these coordinates. For infinite coupling strength the relative coordinates relax very fast to zero and the stationary probability distribution is a δ-function, whereas for finite strength it has a nonzero variance which is determined self-consistently. The results for finite systems with strong but finite coupling are compared with data from simulations and a good agreement is observed.

DY 18.7 Wed 11:15 H48

Crooks' Fluctuation Theorem for a Process on a 2D Fluid Field — •Julia Gundermann[1], Jochen Bröcker[2], and Holger Kantz[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Meteorology, University of Reading, UK

We investigate the behavior of two-dimensional inviscid and incompressible flow when pushed out of dynamical equilibrium. We use the 2D vorticity equation with spectral truncation on a rectangular domain. For sufficiently large number of degrees of freedom, the equilibrium statistics of the flow can be described through a canonical ensemble approach with two conserved quantities, energy and enstrophy. To perturb the system out of equilibrium, we change the shape of the domain according to a protocol, which changes the kinetic energy but leaves the enstrophy constant. We interpret this as doing work to the system. Evolving along a forward and its corresponding backward process, we show that the statistics of the work performed satisfies Crooks' relation $P_f(W)/P_b(-W) = e^{\beta(W-\Delta F)}$. The parameters ΔF and β are given by the formal analogy with the canonical ensemble as the free energy difference and, respectively, the inverse temperature $1/k_BT$.

DY 18.8 Wed 11:30 H48

Vortex arrays as emergent collective phenomena for circle swimmers — •Andreas Kaiser and Hartmut Löwen — Institut für Theoretische Physik II: Weiche Materie, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany

Collective properties of many rod-like circle swimmers are explored by computer simulations in two spatial dimensions. In the model considered, the center of mass of a single swimmer moves on a circle with radius R. Therefore the model provides an interpolation between an interacting self-propelled-rod model for linear swimmers ($R \to \infty$) [1] and that of interacting passive rotors ($R = 0$) [2]. We map out the state diagram for various swimmer densities and radii R. We charac-

terize vortices of single swimmers and vortices of swimmer pairs using structural and dynamical diagnostics. Furthermore, a simple theory is proposed to predict the topology of the state diagram.

[1] H. H. Wensink and H. Löwen, J. Phys.: Condens. Matter **24**, 464130 (2012).

[2] R. Kirchhoff and H. Löwen, EPL **69**, 291 (2005).

DY 18.9 Wed 11:45 H48

Globally Coupled Nonlinear Systems with Additive Noise — •Rüdiger Kürsten[1,2], Susanne Gütter[1], and Ulrich Behn[1] — [1]Institut für Theoretische Physik, Brüderstr. 16, 04103 Leipzig — [2]Max-Planck-Institut für Mathematik in den Naturwissenschaften, Inselstr. 22, 04103 Leipzig

We consider the overdamped motion of N harmonically coupled particles in a double well potential under the influence of additive Gaussian white noise. System parameters are noise strength, coupling strength and potential barrier height. In the limit $N \to \infty$ the system exhibits a continous phase transition from a symmetric to a non-symmetric state.

Given any two parameters, positive, there exists a unique critical value for the third parameter, separating the symmetric from the non-symmetric parameter regime.

An inequality for the parameters holding for any critical point is shown and the critical potential barrier is asymptotically calculated. The critical potential barrier reaches the bounds of the inequality for strong coupling or weak noise and for weak coupling or strong noise.

The critical exponents for the order parameter and the susceptibility are computed and universality of the amplitude ratio of the susceptibilities is shown.

Invited Talk DY 18.10 Wed 12:00 H48

The physics of information: from Maxwell's demon to Landauer — •Eric Lutz — Freie Universität Berlin

We discuss the intimate connection existing between information theory and thermodynamics. We focus on two complementary aspects: 1) the gain of information with Maxwell's famous demon and 2) the erasure of information with Landauer's principle. We further present recent experiments that have for the first time demonstrated the equivalence between information and thermodynamics.