DY 34: Statistical Physics: Far From Equilibrium II

Time: Wednesday 16:45–18:15 Location: ZEU 250

DY 34.1 Wed 16:45 ZEU 250

Lane formation of colloidal particles driven by gravity — •Marc Isele, Kay Hofmann, and Peter Nielaba — Physics Department, University of Konstanz, Konstanz, Germany

Systems of particles that move with differing relative speeds as a counterpart to the movements of pedestrians and crowds have been shown to form a so-called lane structure. We simulate a quasi two dimensional system of two spherical particle types of different sizes driven by gravity. The particles are confined by hard walls orthogonal to the driving force and we employed Brownian Dynamics simulations (without hydrodynamic interactions). We found that the particles formed the well-known lane structure rather quickly. In this formation process the particles form slanted boundaries between the soon to be lanes which leads to regions of high and low densities. In the steady state we further found that the lanes closest to the hard walls were always occupied by the smaller particles (via something we call a funneling process). We also analyzed a wide variety of parameters giving us an optimized system for lane formation. Our work shows that the lane formation of driven particles is a phenomenon with a lot of different aspects that can depend heavily on the chosen system.

DY 34.2 Wed 17:00 ZEU 250

Time-reversal symmetries and equilibrium-like Langevin equations — •Lokrshi Prawar Dadhichi and Klaus Kroy — ITP, Leipzig University, Brüderstraße 15, 04103, Leipzig

Graham has shown in Z. Physik B 26, 397-405 (1977) that a fluctuation-dissipation relation can be imposed on a class of nonequilibrium Markovian Langevin equations that admit a stationary solution of the corresponding Fokker-Planck equation. Here we show that the resulting equilibrium form of the Langevin equation is associated with a nonequilibrium Hamiltonian and ask how precisely the broken equilibrium condition manifests itself therein. We find that this Hamiltonian need not be time reversal invariant and that the "reactive" and "dissipative" fluxes loose their distinct time reversal symmetries. The antisymmetric coupling matrix between forces and fluxes no longer originates from Poisson brackets and the "reactive" fluxes contribute to the ("housekeeping") entropy production, in the steady state. The time-reversal even and odd parts of the nonequilibrium Hamiltonian contribute in qualitatively different but physically instructive ways to the entropy. Finally, this structure gives rise to a new, physically pertinent instance of frenesy.

DY 34.3 Wed 17:15 ZEU 250

Quantum and classical contributions to entropy production in fermionic and bosonic Gaussian systems — •Krzysztof Ptaszyński[1,2] and Massimiliano Esposito[2] — [1]Institute of Molecular Physics, Polish Academy of Sciences, Mariana Smoluchowskiego 17, 60-179 Poznań, Poland — [2]Complex Systems and Statistical Mechanics, Physics and Materials Science Research Unit, University of Luxembourg, L-1511 Luxembourg, Luxembourg

As previously demonstrated, the entropy production – a key quantity characterizing the irreversibility of thermodynamic processes – is related to generation of correlations between degrees of freedom of the system and its thermal environment. The natural question appears whether such correlations are of a classical or a quantum nature, namely, whether they are accessible through measurements. We deal with this problem by investigating fermionic and bosonic Gaussian systems. It is shown that for fermions the entropy production is mostly quantum due to parity superselection rule which restricts the set of physically allowed measurements to projections on the Fock states, which significantly limits the amount of classically accessible correlations. In contrast, in bosonic systems a much larger amount of correlations can be accessed through Gaussian measurements. Specifically, while quantum contribution may be important at low temperatures, in the high temperature limit the entropy production corresponds to purely classical position-momentum correlations.

DY 34.4 Wed 17:30 ZEU 250

Optimal power extraction from active particles with hidden states — •Luca Cocconi[1,2], Jacob Knight[2], and Connor Roberts[2] — [1]The Francis Crick Institute, London — [2]Imperial College, London

We identify generic protocols achieving optimal power extraction from a single active particle subject to continuous feedback control under the assumption that the instantaneous velocity, but not the fluctuating self-propulsion velocity, is accessible to direct observation. Our Bayesian approach draws on the Onsager-Machlup path integral formalism and is exemplified in the cases of free run-and-tumble and active Ornstein-Uhlenbeck dynamics in one dimension. Such optimal protocols extract positive work even in models characterised by time-symmetric positional trajectories and thus vanishing informational entropy production rates. We argue that the theoretical bounds derived in this work are those against which the performance of realistic active matter engines should be compared.

DY 34.5 Wed 17:45 ZEU 250

Driving a first-order phase transformation by quenching the density: Unleashing hidden states — •Miriam Klopotek[1], Martin Oettel[2], and Hans Joachim Schöpe[2] — [1]University of Stuttgart, SimTech Cluster of Excellence EXC 2075, Stuttgart, Germany — [2]University of Tübingen, Institute for Applied Physics, Tübingen, Germany

Abruptly increasing the number density, the primary order parameter of a many-particle system, is a basic mechanism to drive a first-order phase transition – elementary for athermal systems and thus for the solidification process from a fluid. A better-known experiment on thermal systems is quenching the temperature down to below the critical point, suddenly 'freezing out' the original degrees of freedom, whereafter the system densifies locally upon response. A density quench, in turn, intervenes directly and globally on the order parameter. A manifest example is thin film growth. As dynamical arrest is imminent, 'hidden' metastable states appear. We employ kinetic Monte Carlo simulations of a simple lattice model of sticky hard rods under quasi-2D confinement, gradually growing a full monolayer under different quench (growth) rates. The phenomenology is extremely rich: At least five distinct, non-classical phase transformation pathways are identified in this most simple model. They 'tile' a corresponding dynamical control diagram.

DY 34.6 Wed 18:00 ZEU 250

New phases and peculiar fluctuations in nonreciprocal systems — •Sarah Loos — DAMTP, University of Cambridge, UK

Nonreciprocal interactions, i.e., interactions that violate the *actio=reactio* principle, occur in various biological and artificial nonequilibrium systems on a wide range of scales. For example, a bird in a flock may react to the movements of the bird in front of it, while the reverse interaction is zero, simply due to missing visual information. Recent research shows that the occurrence of such nonreciprocal interactions can have a dramatic impact on the self-organization of many-body systems [1], and on their thermodynamic properties [2]. In this talk, we will consider a nonequilibrium lattice model with vision cone interactions [3], and show how the presence of nonreciprocal interactions can lead to the emergence of new phases and peculiar fluctuations.

[1] Fruchart, Non-reciprocal phase transitions, Nature (2021).
[2] S.A.M. Loos and S.H.L. Klapp, NJP 22, 123051 (2020).
[3] S.A.M. Loos, S.H.L. Klapp, and T. Martynec, ArXiv:2206.10519 (2022).