# DY 24: Dynamics and Statistical Physics - Open Session

Time: Tuesday 11:00–13:00 Location: DYb

DY 24.1 Tue 11:00 DYb

**Analysing and Optimizing Nonlinear Memory Capacity of Photonic Reservoir Computing** — •Felix Köster[1], Serhiy Yanchuk[2], and Kathy Lüdge[1] — [1]Institut für Theoretische Physik, TU Berlin, Hardenbergstraße 36, 10623 Berlin — [2]Institut für Mathematik, TU Berlin, Hardenbergstraße 36, 10623 Berlin

Reservoir computing is a neuromorphic inspired machine learning paradigm that utilizes the naturally occurring computational capabilites of dynamical systems. In this work, we investigate the linear and nonlinear memory capacity of a delay-based class-A and class-B-laser reservoir computer via eigenvalue analysis and numerical simulations. We show that these two quantities are deeply connected, and thus the reservoir computing performance is predictable by analyzing the eigenvalue spectrum. We introduce two new quantities to describe the influence of the eigenvalue spectrum on the reservoir computer performance. The insight won by the eigenvalue analysis yields understanding and thus helps applying better performing reservoir systems for a broader range of tasks.

DY 24.2 Tue 11:20 DYb

**Dissipative nonequilibrium synchronization of topological edge states via self-oscillation** — •Christopher W. Wächtler[1,2,3], Victor M. Bastidas[3], Gernot Schaller[1], and William J. Munro[3,4] — [1]Institut für Theoretische Physik, Berlin, Germany — [2]Max-Planck Institut für Physik komplexer Systeme, Dresden, Germany — [3]NTT Basic Research Laboratories, Atsugi, Japan — [4]National Institute of Informatics, Tokyo, Japan

The interplay of synchronization and topological band structures with symmetry protected midgap states under the influence of driving and dissipation is largely unexplored. Here we consider a trimer chain of electron shuttles, each consisting of a harmonic oscillator coupled to a quantum dot positioned between two electronic leads. Each shuttle is subject to thermal dissipation and undergoes a bifurcation towards self-oscillation with a stable limit cycle if driven by a bias voltage between the leads [1]. By mechanically coupling the oscillators together, we observe synchronized motion at the ends of the chain, which can be explained using a linear stability analysis. Because of the inversion symmetry of the trimer chain, these synchronized states are topologically protected against local disorder [2]. Furthermore, with current experimental feasibility, the synchronized motion can be observed by measuring the dot occupation of each shuttle. Our results open another avenue to enhance the robustness of synchronized motion by exploiting topology.

[1] C. W. Wächtler et al., NJP 21, 073009 (2019).
[2] C. W. Wächtler et al, PRB 102, 014309 (2020).

DY 24.3 Tue 11:40 DYb

**Athermal Clustering and Jamming of Active Particles** — •Michael Schmiedeberg — Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

In simulations of overdamped, repulsive, active particles in two dimensions at zero temperature the formation of clusters is observed. Note that it is not the temperature (as for mobility-induced phase transitions in thermal systems) but the unjamming dynamics that competes with the activity.

To be specific, large clusters that are even jammed in the inside only occur for intermediate activities. Decreasing the activity unjams the system and increasing the activity breaks up the clusters. Our simulations are in agreement with our results in [1], where athermal clustering has been studied in three dimensions in a simplified model system.

Our results demonstrate that even in the absence of thermal fluctuations a complex clustering behavior can be observed in active systems. An interesting task for future works will be to further compare the relation between the athermal clustering and mobility-induced phase transitions in thermal systems to the relation between athermal jamming and thermal jamming.

[1] M. Maiti and M. Schmiedeberg, EPL 126, 46002 (2019).

DY 24.4 Tue 12:00 DYb

**Unravel the rotational properties of a squirmer in viscoelastic fluids** — •Kai Qi[1], Marco De Corato[2], and Ignacio Pagonabarraga[1] — [1]CECAM, EPFL, Lausanne, Switzerland — [2]IBEC, BIST, Barcelona, Spain

We investigate the rotational motion of a single swimmer in viscoelastic fluids via Lattice Boltzmann (LB) simulations. Here, the generic squirmer model is employed and fluid viscoelasticity is achieved by added flexible polymer chains. The interplay of activity and boundary conditions between the squirmer and polymers on the squirmer's rotational motion is addressed. For Reynolds number close to unity, the rotational diffusion of a pusher/puller that employs the no-split boundary condition is enhanced over an order of magnitude. This is mainly due to the asymmetric torques generated during the heterogeneous collisions between the squirmer and polymers. However, this enhancement is about 5 times weaker when a short-range repulsion between squirmer's surface and monomers is used. By increasing system viscosity, we decrease the Reynolds number by an order of magnitude. Consequently, polymer's motility is suppressed profoundly. We find that the rotational diffusion coefficients of a pusher/neutral swimmer obtained from two boundary conditions are nearly identical. But the rotational enhancement of a puller with a no-slip boundary condition is twice stronger compared with the one exploiting short-range repulsion. This is because collisions occur mainly in the front of a puller due to its special swimming scheme.

DY 24.5 Tue 12:20 DYb

**Transport coefficients of active particles: reverse perturbations and response theory** — •Thomas Ihle[1], Arash Nikoubashman[2], Sven Stroteich[1], and Rüdiger Kürsten[1] — [1]Greifswald University — [2]Johannes-Gutenberg-University Mainz

The reverse perturbation method [1] for shearing simple liquids is extended to the Vicsek model (VM) of self-propelled particles. The sheared systems exhibit a skin effect: Momentum that is fed into the boundaries of a layer decays mostly exponentially toward the center of the layer. It is shown how the shear viscosity and the momentum amplification coefficient can be obtained by fitting this decay with an analytical solution of the hydrodynamic equations for the VM. The viscosity of the VM consists of two parts, a kinetic and a collisional contribution. Here, a novel expression for the collisional part is derived by an Enskog-like kinetic theory [2]. In agent-based simulations, using several methods to measure transport coefficients, we find excellent agreement between these different methods and also good agreement with the theoretical predictions. In addition, we introduce a response theory that allows us to verify the analytical predictions of kinetic theory and to obtain expressions for non-local transport coefficients. [1] F. Müller-Plathe, Phys. Rev. E 59, 4894 (1999), [2] A. Nikoubashman, T. Ihle, Phys. Rev. E 100, 042603 (2019)

DY 24.6 Tue 12:40 DYb

**Long-time diffusion and energy transfer in mixtures of particles with different temperatures** — •Efe Ilker[1,2], Michele Castellana[1], and Jean-François Joanny[1,3] — [1]Institut Curie, Paris, France — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [3]Collège de France, Paris, France

In biological systems, crowding and composition are key factors affecting the rates of material transport while nonequilibrium aspects of active systems enrich this dynamics from molecular scales to cell populations. Transport properties of solute particles at long timescales differ from their short-timescale behavior due to interactions between the constituent particles. The collisions generate additional friction on a particle, while on top of that, for nonequilibrium (active) systems, the collisions can also lead to an exchange of energy between different constituents. Thus, the long-time diffusion coefficient of a tagged particle is shaped by the interplay between the effective friction and the energy transfer. Using the multiple temperature model, we probe these effects in dilute solutions and derive long-time friction and self-diffusion coefficients as a function of volume fractions, sizes and temperatures of particles. At these long timescales, we show that the tagged particle experiences a size-dependent "bath" temperature which stems from the interparticle energy transfer.