DY 58: Poster: Nonlinear Dynamics; Pattern Formation; Networks; Delay Systems; Synchronization

Time: Thursday 15:00–18:00 Location: P1C

DY 58.1 Thu 15:00 P1C

Studying free energy landscapes of peptides with neural networks — •Simon Lemcke and Thomas Speck — Institute of Physics, Mainz , Germany

Molecular dynamics simulations generate high dimensional data. A recurrent challenge in computational sciences is to perform a dimensionality reduction and to identify the relevant collective variables. Here we employ EncoderMap, which is a variational autoencoder type of neural network, to perform a structure-based reduction to a low-dimensional latent space for a short peptide. We then investigate the suitability of this latent space as collective variables in terms of the free energy and the conformational dynamics.

DY 58.2 Thu 15:00 P1C

Interaction of topological localized states in excitable delayed systems — •Florian Eckel[1], Leon Munsberg[1], Julien Javaloyes[2], and Svetlana Gurevich[1] — [1]Institut fuer theoretische Physik (WWU), Muenster, Germany — [2]Universitat de les Illes Balears, Palma, Spain

We are interested in the dynamics of topological localized states (LSs) in a injection-locked semiconductor laser with a delayed feedback loop. Instead of a depth model describing the time evolution of the electrical field and carriers, a simple delayed Adler equation for the phase of the field can be derived. We explore the interaction between LSs in the delayed Adler equation and show an intricate non-reciprocal behavior. Furthermore, we derive a reduced model for the motion of the centers of the interacting LSs and compare it to the results obtained by direct numerical simulations.

DY 58.3 Thu 15:00 P1C

Influence of time-delayed feedback on the dynamics of temporal localised structures in a passively mode-locked semiconductor laser — •Thomas Seidel[1], Julien Javaloyes[2], and Svetlana Gurevich[1,3] — [1]Institute for Theoretical Physics, University of Münster, Wilhelm-Klemm-Straße 9, 48149 Münster, Germany — [2]Departament de Física, Universitat de les Illes Balears, Carretera Valldemossa km 7.5, 07122 Palma, Spain — [3]Center for Nonlinear Science (CeNoS), University of Münster, Corrensstraße 2, 48149 Münster, Germany

We are interested in the influence of the time-delayed optical feedback in the dynamics of temporal localised structures (LSs) in the output of a semiconductor laser with saturable absorber. We use a delayed differential equation model for a ring geometry where the gain medium is coupled to a saturable absorber and a narrow band optical filter. Using a combination of direct time simulations and path-continuation methods we shall show that the presence of feedback can lead to a number of interesting regimes including the generation of satellite trains on the LS's side or can induce a coherence between LSs.

DY 58.4 Thu 15:00 P1C

Dynamic phases of magnetic gears — •Stefan Hartung and Ingo Rehberg — Universität Bayreuth

We investigate the coupling of two rotating spherical magnets experimentally. Geometries in which the driven magnet is phase-locked to the driving one are so-called cogging free couplings [1]. We find that deviations from this arrangement as well as an increasing driving frequency lead towards different kinds of more complex dynamical behavior. The experimental results are compared to a model based on pure dipole-dipole interaction and are summarized in a phase diagram that gives insight into the possibilities of technical implementation of these kinds of couplings.

[1] Exploring cogging free magnetic gears; Stefan Borgers, Simeon Völkel, Wolfgang Schöpf, and Ingo Rehberg; American Journal of Physics 86, 460 (2018); https://doi.org/10.1119/1.5029823.

DY 58.5 Thu 15:00 P1C

Ultrafast soliton interaction via Raman scattering — •Alexandra Völkel and Georg Herink — Experimental Physics VIII, University Bayreuth, Germany

Recent real-time studies revealed interactions of ultrashort soliton pulses in a femtosecond oscillator., i.e. bound states at discrete temporal binding separations [1]. We investigate the impact of the non-instantaneous nonlinear response of the laser gain medium onto the interpulse dynamic coupling. Specifically, we analyze the contribution of coherent phonons driven by impulsive Raman scattering. Employing a sensitive pump-probe scheme, we characterize the response of the nonlinear refractive index in the time domain and discuss the coupling process.

[1] Herink et al., Real-time spectral interferometry probes the internal dynamics of femtosecond soliton molecules. Science, 356 (2017)

DY 58.6 Thu 15:00 P1C

Measuring the relative importance of network constituents: A perturbation-based approach — •Timo Bröhl[1,2] and Klaus Lehnertz[1,2,3] — [1]Dept. of Epileptology, University of Bonn, Bonn, Germany — [2]Helmholtz Institute for Radiation and Nuclear Physics, University of Bonn, Bonn, Germany — [3]Interdisciplinary Center for Complex Systems, University of Bonn, Bonn, Germany

Investigating complex dynamical systems with methods from network theory has become a prominent approach in diverse areas of science, ranging from physics to the neurosciences. The powerful framework of graph theory allows characterization of a network ranging from to global to the local scale. We investigate the impact of small network perturbations on importance of network constituents (nodes and edges) as accessed with various centrality concepts. Three types of perturbations are applied on the edge level of paradigmatic network topologies with varying sizes and edge densities. Results indicate a close relationship between characteristics of the applied perturbations and the importance ranking of both nodes and edges. This relationship however differs for different network topologies and depends on the applied centrality concept. Our perturbation-based approach may be advantageous to identify spurious or salient edges in networks derived from empirical data.

(This work was supported by the Deutsche Forschungsgemeinschaft; Grant No. LE660/7-1)

DY 58.7 Thu 15:00 P1C

Hidden Markov dynamics of the chaotic diffusion of dissipative solitons — •Tony Albers[1], Jaime Cisternas[2], and Günter Radons[1] — [1]Institute of Physics, Chemnitz University of Technology, Chemnitz, Germany — [2]Facultad de Ingeniería y Ciencias Aplicadas, Universidad de los Andes, Santiago, Chile

Dissipative solitons are persistent localized solutions which are the result of a complicated balance between dispersion and nonlinear effects as well as dissipation and energy gain. These structures can show interesting dynamical behaviors such as explosions, i.e., transient enlargements of the solitons that lead to spatial displacements if the explosions are asymmetric. Due to the chaotic nature of the underlying soliton dynamics, the sequence of spatial jumps as well as the inter-explosion times seem to be random thus leading to a random-walk kind of motion [1]. In this contribution, we show that the sequence of spatial shifts of exploding dissipative solitons in a prototypical complex Ginzburg-Landau equation, known, e.g., from nonlinear optics, is governed by a hidden Markov process with continuous output densities. It captures the non-trivial decay of correlations of jump widths and symbol sequences representing the soliton motion, the statistics of anti-persistent walk episodes and the multimodal density of the jump widths. This is the first example of a physically meaningful reduction of an infinite-dimensional deterministic dynamics to one of a probabilistic finite state machine.

[1] Tony Albers, Jaime Cisternas and Günter Radons, New J. Phys. **21** 103034 (2019)

DY 58.8 Thu 15:00 P1C

Learning in Simple Heteroclinic Networks — •Maximilian Voit and Hildegard Meyer-Ortmanns — Jacobs University Bremen, Bremen, Deutschland

Heteroclinic networks provide a promising candidate attractor to generate reproducible sequential series of metastable states. From an engineering point of view it is known how to construct heteroclinic networks to achieve certain dynamics, but a data based approach for the inference of heteroclinic dynamics is still missing. We present a method by which a template system dynamically learns to mimic an input sequence of metastable states. For this purpose, the template is unidirectionally, linearly coupled to the input. At the same time, the learning dynamics causes an adaptation of the eigenvalues of the template in order to minimize the difference of template dynamics and input sequence. Thus, after the learning procedure, the trained template constitutes a model with dynamics that are most similar to the training data. We demonstrate the capabilities and possible difficulties of this method at different examples. Our approach may be applied to infer the topology and the connection strength of a heteroclinic network from data in a dynamic fashion and may serve as a model for learning in the context of winnerless competition.

DY 58.9 Thu 15:00 P1C

Simulating nano-particle networks to solve classification problems — •Marlon Becker[1], Bram de Wilde[2], Wilfred van der Wiel[2], and Andreas Heuer[1] — [1]Institut für physikalische Chemie, Westfälische Wilhelms-Universität Münster — [2]Faculty of EEMCS, CTIT and MESA+ Institutes for ICT Research and Nanotechnology, University of Twente

The use of Artificial Neural Networks to solve various problems is a method of rapidly growing interest in nearly all fields of modern science. Instead of simulating Neural Networks, neuromorphic computing attempts to directly build hardware structures that can be utilized for sophisticated tasks. Recently promising experimental work was published (Classification with a disordered dopant atom network in silicon (2019), Nature (in press)) that is based on nano-particle networks (such as boron doped silicon semiconductors or gold nano-particles) to solve various classification problems, including the linearly inseparable XOR and XNOR gate. To control the desired functionality, external voltages are applied to the devices. In this work different approaches to simulate these neuromorphic networks in physical models are provided. By defining fitness functions, energy-like landscapes as a function of the external voltages are obtained. Different methods to find minima of these landscapes in which the desired functionalities can be found are investigated. To further optimize the experimental devices, general scaling behavior as well as the system scale necessary to reach the desired functionality is analyzed.

DY 58.10 Thu 15:00 P1C

Detection of defects in soft quasicrystals with neural networks — •Ali Döner and Michael Schmiedeberg — Institut für Theoretische Physik I, FAU Erlangen-Nürnberg, Germany

The aim of this work is to employ a neural network for the detection of defects in quasicystalline patterns. Quasircrystals are aperiodic, but they exhibit a longe-range order and in principle can possess any discrete rotational symmetry. We consider quasicrystalline patterns with dodecagonal symmetry as they occur most often in soft matter systems. Our goal is to detect the positions of dislocations as well as their Burgers vector. Our training as well as test data sets consist of calculated patterns with one randomly placed dislocation with one out of six distinguishable Burgers vectors. Our trained neural network is able to recognize the type of the Burgers vector perfectly. The position of the dislocation is recognized up to a mean deviation from the real position of about 0.13 of the small length scale in the quasicrystals. In future, we want to train the network with patterns that contain multiple dislocations as well as phasonic excitations.

DY 58.11 Thu 15:00 P1C

Adaptively coupled phase oscillators with discontinuous plasticity rule — •Sören Christian Nagel[1], Rico Berner[1], Eckehard Schöll[1], and Serhiy Yanchuk[2] — [1]Institut für theoretische Physik TU Berlin, Berlin, Germany — [2]Institut für Mathematik TU Berlin, Berlin, Germany

Memory and the development of neuronal populations have been widely studied using discontinuous forms of spike timing-dependent synaptic plasticity (STDP). Despite the acceptance of these approaches in the field of neuroscience, very little is known about the dynamical features that are provided by the discontinuities.

For this purpose, we study a system of two coupled phase oscillators with STDP. Our analysis reveals various dynamical scenarios, namely, the appearance of a generalized fixed point as the source of in-phase synchrony, different types of limit cycles, and unexpected bifurcations due to the discontinuous STDP.

DY 58.12 Thu 15:00 P1C

Data-driven identification of sparsely observed stochastic systems — •Dimitra Maoutsa and Manfred Opper — Technical University of Berlin, Berlin, Germany

Stochastic differential equations naturally occur in many fields in science and engineering, arising often as descriptions of systems with unresolved fast degrees of freedom. Usually, the underlying deterministic dynamics (i.e. drift function) and complete path trajectories of such systems are unknown, but instead we only have discrete time state observations at hand. Existing inference methods for such systems, either consider detailed parametric drift models, or assume densely observed trajectories for non-parametric Gaussian process drift estimation. Here, we present a data-driven approach for recovering nonlinear stochastic systems from sparse state observations. By introducing a novel method for simulating stochastic bridges consistent with the observed time series state space structure, we effectively create dense sample paths required for non-parametric drift estimation. We illustrate the power of our method on a number of simulated canonical dynamical systems, demonstrating thereby its potential and accuracy compared to existing frameworks.

DY 58.13 Thu 15:00 P1C

Isospectral reductions and pretty good state transfer — Malte Röntgen[1], Nikolaos Palaiodimopoulos[2], •Christian Morfonios[1], Ioannis Brouzos[2], Maxim Pyzh[1], Fotios Diakonos[2], and Peter Schmelcher[1] — [1]Centre for Optical Quantum Technologies, University of Hamburg — [2]Department of Physics, University of Athens

Pretty good state transfer (PGST) denotes the transfer of a single site excitation with fidelity arbitrarily close to unity at a finite transfer time in a network system. It was recently shown that PGST generally arises in a network under certain conditions on its characteristic polynomial factors corresponding to eigenvectors with opposite parity on the input and target sites. We here combine this result with isospectral reductions of networks over site pairs, exploiting a dimensionally reduced form of the associated Hamiltonians to facilitate the design of PGST. We present a variety of setups thus made to support PGST and further show how, relying on the concept of compact localized states, the obtained networks can be additionally equipped with storage of input and target states.

DY 58.14 Thu 15:00 P1C

An MCMC method to determine Complex Network properties — •Oskar Pfeffer — Potsdam Institute for Climate Impact Research

We apply the Markov Chain Monte Carlo (MCMC) algorithm Metropolis Hastings to sample graphs with specific properties. The generated networks are analysed using the measures of clustering and characteristic length that are used in literature to detect small world graphs. We show that optimizing these measures in a graph do not produce typical small world graphs.

DY 58.15 Thu 15:00 P1C

Formulation of Voltage Dynamics in Complex Quantities — •Hannes Vogel[1,3] and Frank Hellmann[2] — [1]Humboldt-Universität zu Berlin, Berlin, Germany — [2]Potsdam-Institut für Klimafolgenforschung, Potsdam, Germany — [3]Stockholm University, Stockholm, Sweden

Understanding the stability of voltage dynamics in power grids is essential to the development of decentralized power networks for renewable energy sources. Current voltage dynamics models are motivated either by physics or control theory. We aim to formulate the power grid dynamics in terms of complex voltages, which combine the dynamics of rotor angle, frequency and voltage amplitude. To get a better overview of the properties of different models and to find criteria for classification, a common general formulation is needed. Indeed, such a formulation is obtained by writing the differential equations in a complex power series. Therefore the mathematical structure of the Stuart-Landau equation functions as a prototype.