DY 50: Poster: Nonlinear Systems, Patterns, Flows ..

Time: Thursday 15:00–18:00 Location: Poster B2

DY 50.1 Thu 15:00 Poster B2

Relaxation of hydrogen bond network in water subject to an E-field — •Andreas Baer[1], David Matthew Smith[2,3], and Ana-Sunčana Smith[1,2] — [1]PULS Group at the Institute for Theoretical Physics, FAU Erlangen-Nürnberg, Germany — [2]Division of Physical Chemistry, Institute Ruđer Boŝcović, Zagreb, Croatia — [3]Computer Chemistry Center, FAU Erlangen-Nürnberg, Germany

Most of the amazing properties of liquid water stem from the fluctuations in the uninterrupted network of hydrogen bonded molecules.[1] One such phenomena is the splitting of transport coefficients in an electric field, which is not yet understood from the microscopic point of view. We address this by investigating the influence of an externally imposed electric field on liquid water at ambient conditions with the use of extensive molecular dynamics and rigorous statistical analysis.[2] The time dependent stress relaxations are related to different individual and cooperative motions of water molecules, identifying a filed-induced relaxation, occurring on the picosecond time scale, which was hitherto not reported in the literature. This process is shown to be primarily responsible for the anisotropic splitting of the shear viscosity in electric fields. It is further associated with cooperative transitions of several hydrogen bonded water molecules between the states of zero torque imposed by the field.[3] [1] Luzar, A.; Chandler, D. Nature 1996 379, 55-57. [2] Milicevic Z., Marrink S. J., Smith A.-S., Smith D. M. J. Mol. Mod. 2014 20, 2359 [3] Baer A., Milicevic Z., Smith D. M., Smith A.-S., submitted

DY 50.2 Thu 15:00 Poster B2

Reduced order model for the velocity gradient dynamics in fully developed turbulence — •Leonhard A. Leppin[1,2] and Michael Wilczek[2] — [1]Georg-August-Universität Göttingen, Germany — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Fully developed homogeneous isotropic turbulence exhibits statistically and geometrically complex small-scale structures. A promising approach to advance the understanding of these structures has been to formulate low-dimensional dynamical systems for the velocity gradient. However, the evolution equation of the velocity gradient tensor along Lagrangian fluid particle trajectories contains non-local terms, e.g. the pressure Hessian, which prohibit a statistically closed description of the dynamics. Here, we formulate a general closure by employing results from the theory of tensor function representation. We find that the conditional pressure Hessian can be expressed in terms of only seven known tensors with unknown coefficients that depend on the tensor invariants. To investigate the influence of the different terms of the closure we numerically integrate an ensemble of stochastic differential equations whose coefficients are dynamically adapted such that the ensemble fulfills a number of physical constraints of homogeneous turbulence. By exploring the general tensorial structure of the unclosed terms and the resulting nonlinear dynamics, our work contributes to an improved understanding of the small-scale motions in turbulence by means of low-dimensional dynamical systems.

DY 50.3 Thu 15:00 Poster B2

Synchronization in optical neurons — •Felix Köster[1], Benjamin Lingnau[1,2], Philipp Hövel[1,3], and Kathy Lüdge[1] — [1]Institute of theoretical Physics, Technische Universität Berlin — [2]Physics Department, University College Cork, College Rd, Irland — [3]School of Mathematical Science, University College Cork, Irland

Recent studies have shown that information processing in neurons could be positively influenced by noise via noise-induced spiking. Inspired by this and the similar behavior of neurons and lasers, a network of quantum dot (QD) lasers is simulated in the steady state (continuous intensity output) close to a saddle-node infinite period (SNIPER) bifurcation. In this setup the QD lasers can be excited through noise into emitting pulses, i.e. spikes. Then the QD laser network can exhibit the counterintuitive effect of coherence resonance on the global network scale. We find that the regularity of noise-induced spiking has a maximum in its correlation at a finite value of the noise strength. We show that this collective coherence resonance effect is connected to the stability of the synchronized manifold and the global SNIPER bifurcations of the network. Additionally a scheme is introduced for identifying the network and parameter configurations where this collective coherence resonance effect can be detected.

DY 50.4 Thu 15:00 Poster B2

Simulation of horizontally rotating compressible convection: Towards the Boussinesq limit — •Kevin Lüdemann and Andreas Tilgner — Institut für Geophysik, Georg-August-Universität Göttingen, Deutschland

The band structure on Jupiter consisting of alternating east and west winds stems from compressible convective motion under the influence of Coriolis force. In order to investigate this structure, a numerical study of an ideal gas is performed in a cuboid geometry with gravitation in vertical direction and rotation around a horizontal axis. This geometry in a 3D case has been investigated before but only with an incompressible fluid in the Boussinesq approximation. Density and temperature scale heights are additional parameters in the compressible equations. Those are varied towards the Boussinesq limit for validation. Furthermore a parameter study of the thermal transport shows a decrease during departure from incompressibility as has also been proposed in prior work. At the same time, plume outbursts loose strength and a crossover from convective rolls to the thermal wind is observed.

DY 50.5 Thu 15:00 Poster B2

Dynamics of magnetic gears — •Stefan Hartung, Simeon Völkel, and Ingo Rehberg — Universität Bayreuth

The coupling of two rotating spherical magnets is investigated experimentally. Those motions where the driven magnet is phase-locked to the driving one are so-called cogging free couplings [1]. We find that configurations not following this condition show a more complex dynamical behavior. The experimental results are compared to a model based on pure dipole-dipole interaction. Technical applications of these kinds of couplings are foreseeable particularly for small machines.

[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 50.6 Thu 15:00 Poster B2

Evolving Transport Networks — •Janosch Brandhorst and Pawel Romanczuk — Institute for Theoretical Biology, Department of Biology, Humboldt Universität zu Berlin, Germany

Ant colonies and slime moulds are known to effectively explore and exploit their environment by setting up a complex transport network. Interestingly, the scales of these networks are much larger than the area a single agent of these colonies can sense. Here, we present an agent-based model of a collective which adapts to explore and exploit arbitrary resource fields. Agents are stationary placed on an randomly generated resource field. In each iteration, an agent can harvest resources from the resource field and collect resources from its neighbours. The efficiency of these processes is dependent on the phenotype of each agent. The phenotype is allowed to evolve during the simulation. The performance of this collective is measured by the amount of resources which is delivered to the centre of the collective. This leads to the self-organized formation of a transport system which effectively assimilates randomly spatial distributed resources in its centre, even though the agents do not have any information about their neighbours, the location of resources nor the location of centre of the collective. Eventually, we are interested in the ability of such collective to adapt to spatio-temporally varying environments.

DY 50.7 Thu 15:00 Poster B2

Work statistics in the classical periodically driven anharmonic oscillator — •Mattes Heerwagen and Andreas Engel — Institut für Physik, Carl von Ossietzky Universität Oldenburg, 26111 Oldenburg, Germany

For a small, time-dependent Hamiltonian system starting in thermal equilibrium the probability distribution of work arises due to the interplay between random initial conditions and deterministic dynamics. This distribution has been studied in detail for several examples of integrable systems. When regular and chaotic motion coexist new mechanisms for phase space mixing arise that will leave signatures in the work statistics.

We consider a classical anharmonic oscillator initially at equilibrium. Then the heat bath is removed and a periodic driving with slowly increasing envelope function is switched on. After reaching a maximum the driving is again switched off smoothly such that the final Hamiltonian coincides with the initial one. By the first law of thermodynamics, the work of the external driving equals the energy change of the system during the process. We determine the probability density $P(E_f|E_i)$ for transitions from initial energy E_i to final energy E_f and deduce from it the work statistics for the periodically driven anharmonic oscillator.

DY 50.8 Thu 15:00 Poster B2

Met Mast Array to measure high temporal and spatial resolution wind fields — •Abdulkarim Abdulrazek, Joachim Peinke, and Michael Hölling — ForWind, Institute of Physics, University of Oldenburg, Oldenburg, Germany

Atmospheric wind fields are turbulent, in which the flow frequently changes speed and direction, creating a sudden increase of wind speed and generation of vortices. Such turbulent flows can affect for example wind turbine loads and performance causing damages resulting in expensive downtimes. In order to study these effects, a met mast array consisting of three meteorological masts will be installed between two wind turbines. The mast array will be equipped with up to XX ultrasonic and cup anemometers. The challenge is how to distribute these anemometers in horizontal and vertical direction to achieve high resolution in time and space. On the poster we will present the concept of the layout of the anemometers based on the detailed analysis of already existing atmospheric measurements data. Therefore, we propose an unevenly distributed arrangement of the anemometers in two dimensions. The anemometers will be distributed according to scaling factor of 2.52n on the three masts which should extract an optimal amount of information on a large range of scales as well as capture finer wind variations and vortices of different sizes.

DY 50.9 Thu 15:00 Poster B2

The parameter space of thermohaline stairs — •Axel Rosenthal and Anderas Tilgner — Friedrich-Hund-Platz 1, 37077 Göttingen

Convection and diffusion in water can be observed when a gradient in temperature or in salinity takes effect on density in presence of gravity. Both gradients can force or stabilize the process. We conducted experiments where the salt gradient is the driving force and simultaneously the temperature gradient is stabilizing in opposite direction, observed by particle image velocimetry (PIV). The question is at which gradients, expressed by Rayleigh numbers, does the transport occure in stable so called "thermohaline stairs"? Thermohaline stairs are a sequence of two flow systems, a finger regime and a large scale circulation.

DY 50.10 Thu 15:00 Poster B2

Wasserklangbilder — •Carla Corsi[1], Thomas Grillenbeck[1,2] und Michael Memminger[3] — [1]Ignaz-Günther-Gymnasium Rosenheim — [2]Rosenheim University of Applied Sciences — [3]Magic Aqua Rosenheim

Die Kunst bei der Erzeugung von Wasserklangbildern liegt darin, das aus dem Physikunterricht bekannte Konzept der *stehenden Welle* dafür zu nutzen, ein faszinierendes Bild zu erzeugen, obwohl man im Grunde *einfach nur Wasser fotografiert*. Klangschwingungen werden über ein Gefäß auf das Wasser übertragen, wodurch in diesem und an seiner Oberfläche, durch die sich ständig durchdringenden und überlagernden Wellen eine Vielzahl eindrucksvoller Strukturen entstehen, welche dann durch besondere Lichtreflexion sichtbar gemacht und fotografiert oder gefilmt werden können.

DY 50.11 Thu 15:00 Poster B2

Semi-classical treatment of chaotic systems — •Sebastian Rosmej — Carl-von-Ossietzky Universität Oldenburg

Up to today chaos is a fascinating but complicated topic in physics. So dealing with quantum chaos is extremely difficult but already the classical treatment of chaotic systems is non-trivial. A helpful bridge between classical and quantum chaos might be the semi-classical approach.

Using time-dependent semi-classical methods simple models are considered where regular and chaotic motion are possible. One example is the periodically driven anharmonic oscillator. A currently investigation of this periodically driven anharmonic oscillator is the derivation of probability distributions for work in the quantum case which is of fundamental interest in physics. An important step in this challenge is the semi-classical treatment of such systems.

DY 50.12 Thu 15:00 Poster B2

Controlling soliton molecules: Driven vibrations and separation switching — •Felix Kurtz[1], Claus Ropers[1], and Georg Herink[2] — [1]IV. Physical Institute - Solids and Nanostructures, University of Göttingen, Germany — [2]Experimental Physics VIII - Ultrafast Dynamics, University of Bayreuth, Bayreuth, Germany

Solitons, localized excitations balanced by dispersion and nonlinearity, are of particular interest in various nonlinear systems. In analogy to real molecules, they can bind together and form "soliton molecules". Here, we study the behavior of soliton molecules in a mode-locked Ti:Sapph laser oscillator. Previously hidden internal dynamics of soliton molecules can now be accessed by employing the time-stretch dispersive Fourier transform (TS-DFT), which enables us to track the double-pulse separation and relative phase in real-time [1].

In the current work, we actively drive internal vibrations over a range of frequencies and amplitudes by weakly modulating the pump power. We resolve internal resonances of the soliton molecule, and detect higher harmonic and subharmonic responses. These observations are related to simulations in the framework of the complex Ginzburg-Landau equation. Beyond perturbative excitations, we apply stronger stimuli, which leads to a reversible switching between discrete pulse separations.

[1] G. Herink, F. Kurtz, B. Jalali, D.R. Solli, C. Ropers, *Science* **356**, 50-54 (2017)

DY 50.13 Thu 15:00 Poster B2

Minkowski Tensors: Robust and Versatile Shape Descriptors — •Fabian Schaller[1,2], Michael Klatt[3], and Sebastian Kapfer[1] — [1]Theoretical Physics, FAU Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Institute of Stochastics, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [3]Department of Physics, Princeton University, Princeton, NJ 08544, USA

Minkowski scalars and tensors are a versatile, sensitive and robust way to quantify shape. Minkowski tensors are explicitly sensitive to anisotropy, relevant for example for elastic moduli or permeability of microstructured materials. Here, we present exemplary applications to real world data and to mathematical models. As examples, we analyze Voronoi and Delaunay tessellations of jammed disk packings and different point patterns. Furthermore we use the Minkowski tensors to analyze objects in gray-scale images. You can explore the possibilities of these shape measures online in our morphometer, an interactive sandbox which will be as well presented at our poster. Further details can be found on our website www.morphometry.org.

DY 50.14 Thu 15:00 Poster B2

Effective Large-Scale Equations in a Model of Passive Scalar Turbulence — •Tobias Bätge[1,2] and Michael Wilczek[1] — [1]Max-Planck-Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Faculty of Physics, University of Göttingen, Germany

Turbulent flows involve dynamics across a wide range of scales. Capturing this multi-scale dynamics remains a theoretical and computational challenge. For many practical applications, a coarse-grained description of the flow is needed, in which the small scales are treated in an effective manner. How can we obtain such effective large-scale equations? Here, we address this problem at the example of a simple, one-dimensional model for the advection of a passive scalar field. Similar to the Kraichnan model, the scalar is advected by a random Gaussian field and subject to diffusion. Despite its simplicity and analytical tractability, this model shows non-trivial features such as intermittency and anomalous scaling. We propose that effective large-scale equations can be obtained by ensemble-averaging over the small-scale velocity fluctuations. We show that this procedure leads to an effective diffusivity reminiscent of phenomenological eddy viscosity models. To test our approach, we quantitatively compare the large-scale statistics of fully resolved simulations with the ones obtained from our effective large-scale equations.

DY 50.15 Thu 15:00 Poster B2

Criticality in high-degree networks — •Lorenz Baumgarten and Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen

Criticality is a topic of interest in current brain research as well as statistical physics. Recently, a previously unknown critical point was discovered in high-degree threshold networks [1]. This paper opened a new possible area of investigation in a so far barely studied region.

Therefore, we further study criticality in high-degree networks and the effects of topological variants on the details of criticality, especially in the light of real critical brain networks.

[1] S. Bornholdt, J. Neto, M. de Aguiar, J. Brum, Inhibition as a determinant of activity and criticality in dynamical networks, arXiv 2017, 1712.08816

DY 50.16 Thu 15:00 Poster B2

Estimating low dimensional dynamical models for molecules — •Max Philipp Holl and Oliver Kamps — Institut für theoretische Physik, Universität Münster, Wilhelm-Klemm-Straße 9, 48149 Münster

The dynamics of molecules is a complex problem involving many degrees of freedom. However different states of the molecular system can often be described by only a few of them. We combine two data driven techniques to calculate a low dimensional representation for these systems and estimate dynamical models for the molecules. First we reduce the dimensionality of a time series using a nonlinear dimensionality reduction algorithm, Scalable ISOMAP [1]. Secondly we estimate the deterministic drift and stochastic driving on this reduced system using a data-driven estimation method, based on the Langevin equation [2].

[1] P. Das et al. Low-dimensional, free-energy landscapes of protein-folding reactions by non-linear dimensionality reduction. Proceedings of the National Academy of Sciences, 103(26):9885-9890, 2006.

[2] R. Hegger and G. Stock. Multidimensional Langevin modeling of biomolecular dynamics. The Journal of Chemical Physics, 130(3):034106, jan 2009.

DY 50.17 Thu 15:00 Poster B2

Complex Data Workflow Management using CaosDB — •Alexander Schlemmer[1,3], Henrik tom Wörden[1,2], Timm Fitschen[1,2], Daniel Hornung[1], Ulrich Parlitz[1,2,3], and Stefan Luther[1,2,3,4,5] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Nonlinear Dynamics, Georg-August-Universität, Göttingen, Germany — [3]German Center for Cardiovascular Research (DZHK), partner site Göttingen, Germany — [4]Institute of Pharmacology and Toxicology, University Medical Center Göttingen, Göttingen, Germany — [5]Department of Physics and Department of Bioengineering, Northeastern University, Boston, USA

Although scientific data has been used in digital formats for a long time, the data management is in many cases flawed and highly ineffective: In many scientific workgroups data files are spread over many devices, hidden in impractical directory tree structures and rarely sufficiently documented or annotated with metadata. Concepts for overcoming these problems, like the FAIR data principles, receive a lot of attention, but practical solutions for data workflow management are far from commonly implemented. Here we propose a data workflow management based on CaosDB (https://arxiv.org/abs/1801.07653) which is able to handle big amounts of complex data. The versatile semantic data model maps various data sources and data structures, such as data from different measurement devices or computer simulation data. In particular, the software includes a powerful and intuitive query language and a system for physical units.

DY 50.18 Thu 15:00 Poster B2

Die Kräfte beim Auseinanderziehen von ineinanderlegen Telefonbüchern — •Anna Treffurth und Thomas Grillenbeck — Ignaz-Günther-Gymnasium Rosenheim

Durch das Ineinanderlegen zweier Telefonbücher, indem man eine Seite des einen auf eine Seite des anderen Telefonbuches legt, entsteht eine potenzielle Reibungskraft. Diese kann je nach Versuchsparametern relativ klein oder extrem groß sein. Sogar so groß, dass sich an unseren regionalen Büchern, die nicht besonders dick sind, sogar eine erwachsene Person hängen kann, ohne dass diese auseinander gezogen werden. Dieses Phänomen und die dafür verantwortlichen Parameter habe ich untersucht.

DY 50.19 Thu 15:00 Poster B2

Wind speed modeling by nested ARIMA processes — •Sokumneth Sim, Philipp Maass, and Pedro Lind — Universität Osnabrück, Barbarastraße 7, 49076 Osnabrück

Wind speed modelling is of increasing interest, both for basic research and for applications, as, e.g. for wind turbines development and strategies to construct large wind power plants. Generally, such modelling is hampered by the non-stationary features of wind speed data that, to a large extent, reflect the turbulent dynamics in the atmosphere. We study how these features can be captured by nested ARIMA models. In this approach, wind speed fluctuations in given time windows are modelled by one stochastic process, and the parameter variation between successive windows by another one. For deriving the wind speed model, we use 20 months data collected at the FINO1 platform at the North Sea and use a variable transformation that best maps the wind speed onto a Gaussian random variable. We find that wind speed increments can be well reproduced for up to four standard deviations. The distributions of extreme variations, however, strongly deviate from the model predictions.

DY 50.20 Thu 15:00 Poster B2

Global Particle Sizing and Velocimetry in Clouds — •Marcel Schröder[1], Philipp Höhne[1], Gholamhossein Bagheri[1], and Eberhard Bodenschatz[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Am Faßberg 17, 37077 Göttingen, Germany — [2]Laboratory of Atomic and Solid State Physics and Sibley School of Mechanical and Aerospace Engineering, Cornell University, Ithaca, NY 14853, USA

Weather forecasts and prediction of precipitation still remain uncertain due to insufficient understanding of cloud physics. This is mainly due to the presence of the large range of spatial and temporal scales within a turbulent environment in which the moist convection, cloud droplet growth and cloud formation take place. Particularly, the role of turbulence in droplet growth between 20 μm and 100 μm in diameter, known as the size gap problem, is not yet resolved. In order to shed light on the coupling of cloud microphysics and turbulence, we have developed a new setup based on Interferometric Particle Imaging (IPI) and Multi-pulse (here four-pulse) Particle Image Velocimetry (MPIV). The combination of IPI and MPIV techniques would allow to simultaneously measure droplet size, 2D spatial distribution, phase, as well as 2D velocity and acceleration. In the first step, we have found optimal parameters for designing the experimental setup. Then, a set of synthetic IPI images is made to assess the particle detection and sizing algorithms for different droplet size distributions and concentrations typically encountered in clouds. Finally, preliminary experiments are also carried out in the lab.

DY 50.21 Thu 15:00 Poster B2

Stable subharmonic patterns in spatially modulated phase separation — •Frederik Thomsen, Mirko Ruppert, and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth, Deutschland

We consider the standard continuum model for phase separation, the Cahn-Hilliard model, and investigate the effects of spatially periodic modulations of the control parameter on the onset of phase separation. We find by analytical approximations and numerical solutions a reduction of the critical value of the control parameter at the onset of modulated phase separation. In addition, we find stable spatial patterns with wavenumbers subharmonic to the modulation wavenumber.

DY 50.22 Thu 15:00 Poster B2

Orientation and coexistence of stripe patterns in small rectangular domains — •Mirko Ruppert and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth, Deutschland

Motivated by experiments on pattern formation in small systems, we investigate the orientation of nonlinear stripe patterns in small, rectangular domains for different boundary conditions along the domain borders. In addition the orientation of stripe patterns is investigated for spatially varying control parameter, which is only supercritical in a small domain. We characterize, how the orientation of a pattern and the coexistence between different stripe orientations depend on the aspect ratio G between the length and the width of a domain. Orientational transitions take place at different values of G for different boundary conditions as well as in the case of control-parameter variations. We present analytical considerations and numerical solutions of the Swift-Hohenberg- model and the Brusselator.

DY 50.23 Thu 15:00 Poster B2

Rectangular wrinkle patterns in modulated skin layers on compliant substrates — •Nancy Mejia Villagran, Fabian Bergmann, Lisa Rapp, and Walter Zimmermann — Universität Bayreuth

We model the post-buckling behavior of wrinkles in thin inhomogeneous solid films supported by a homogeneous substrate under biaxial compression. In thin films on substrates with different compressional loads along the two orthogonal directions, one has a preferred direction (anisotropy). The wave vector of the wrinkles at onset points therefore along the direction with the larger load. If the elastic properties of the thin film are spatially modulated with a modulation wavelength larger than the critical one, we show that rectangular wrinkle patterns are induced for equal biaxial loads, as well as for anisotropic biaxial loads. In the latter case, we find also undulations.

DY 50.24 Thu 15:00 Poster B2

Transition from nonlinear traveling to standing waves in confined systems — •Samuel Grimm, Fabian Bergmann, Lisa Rapp, and Walter Zimmermann — TP1, Universität Bayreuth

In E. coli bacteria, for example, self-organized pole-to-pole oscillations of Min proteins - resembling a short standing wave - ensure correct positioning of the cell division site. The same biochemical reaction leads to traveling protein waves on extended membranes in in vitro experiments. We have shown in [1], that these seemingly contradictory observations can be explained by basic principles of pattern formation: For a complex Swift-Hohenberg model a transition of nonlinear traveling wave patterns in extended systems to reflection-induced standing waves takes place by reducing the system length. We show with this contribution, that the same basic principles of pattern formation cause a transition to standing waves also in the case of a subcritical bifurcation to traveling waves. We also show, how spatiotemporally chaotic traveling wave states can be supressed in favor of standing waves in short systems. We explore this behavior in terms of complex Swift-Hohenberg models with an unconserved and a conserved order-parameter field.

[1] F. Bergmann, L. Rapp, W. Zimmermann, New J. Phys. (Fast track) 20, 072001 (2018)