Dynamics and Statistical Physics Division
Fachverband Dynamik und Statistische Physik (DY)

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Overview of Invited Talks and Sessions

(lecture rooms MA 001, MA 004, and MA 144, Poster area A)

Selected Plenary and Keynote Talks

PV II	Mon	14:00–14:45	H 0105	**The Fragility of Interdependency: Coupled Networks & Switching Phenomena** — •H. Eugene Stanley
PV XVII	Wed	20:00–21:00	Urania	**Windenergie - eine turbulente Sache** — •Joachim Peinke
PV XVIII	Thu	8:30– 9:15	H 0105	**The Complex Physics of Climate Change: Nonlinearity and Stochasticity** — •Michael Ghil

Invited and Topical Talks

DY 2.1	Mon	9:30–10:00	MA 004	**Separation of chiral particles in micro- and nanofluidic systems** — •Ralf Eichhorn
DY 2.10	Mon	12:15–12:45	MA 004	**Melting transition of hard disks** — •Werner Krauth
DY 5.9	Mon	17:00–17:30	MA 004	**Phason dynamics in light-induced colloidal quasicrystals** — •Michael Schmiedeberg, Justus Kromer, Holger Stark
DY 4.11	Mon	17:45–18:15	MA 001	**Environment-induced heating in composite quantum systems** — •Almut Beige
DY 15.1	Wed	9:30–10:00	MA 004	**Fluctuations and State Variables in Driven Granular Materials** — •Karen Daniels
DY 15.13	Wed	13:00–13:30	MA 004	**Impact of interaction effects on hopping transport in driven systems** — •Mario Einax
DY 16.1	Wed	10:00–10:30	MA 144	**Pepsi®–or ☺ interfacial instabilities between magnetic/non-magnetic liquids** — •Reinhard Richter
DY 21.10	Wed	16:45–17:15	MA 144	**Algorithms in statistical physics: Percolation** — •Stephan Mertens, Cristopher Moore
DY 25.1	Thu	9:30–10:00	MA 004	**Through mountains high and valleys low: Ultracold atoms in random potentials.** — •Cord Müller
DY 25.13	Thu	13:00–13:30	MA 004	**Transport beyond Brownian Motion – Persistent correlations** — •Thomas Franosch
DY 27.1	Thu	14:30–15:00	MA 004	**Single particle trajectories and weak ergodicity breaking in ageing systems** — •Ralf Metzler
DY 28.10	Thu	17:15–17:45	MA 144	**Sensitivity and out-of-sample error in data assimilation** — •Jochen Bröcker
DY 31.1	Fri	9:30–10:00	MA 004	**Pair Superfluidity of Constrained Bosons in Two Dimensions** — •Stefan Wessel, Lars Bonnes
DY 31.13	Fri	13:00–13:30	MA 004	**Multifractal fluctuations and Scaling at the three-dimensional Anderson transition** — •Alberto Rodriguez, Louella J. Vasquez, Keith Slevin, Rudolf A. Roemer

Invited talks of the joint focus session Statistics of Cellular Motion (with BP)

Organised by Carsten Beta, Peter Dieterich, Rainer Klages and Lutz Schimansky-Geier.

BP 11.1	Tue	9:30–10:00	H 1028	**Data-driven modeling of cell trajectories: a do-it-yourself kit** — •Henrik Flyvbjerg
BP 11.2	Tue	10:00–10:30	H 1028	**The statistics of eukaryotic chemotaxis** — •Eberhard Bodenschatz
BP 11.3	Tue	10:30–11:00	H 1028	**Dynamics of directed cell migration** — •Albrecht Schwab, Otto Lindemann, Peter Dieterich
BP 11.4	Tue	11:00–11:30	H 1028	**Medley swimming of sleeping sickness parasites** — •Vasily Zaburdaev, Sravanti Uppaluri, Thomas Pfohl, Markus Engstler, Rudolf Friedrich, Holger Stark

Invited talks of the joint focus session Nonlinear Dynamics of the Heart (with BP)

Organised by Ulrich Parlitz

DY 14.1	Wed	9:30–10:00	MA 001	**Modelling Excitation Contraction Coupling** — •Martin Falcke
DY 14.2	Wed	10:00–10:30	MA 001	**Modeling of electrical and mechanical function of the heart** — •Alexander Panfilov
DY 14.3	Wed	10:30–11:00	MA 001	**Mechanisms for calcium alternans** — •Blas Echebarria, Enric Alvarez-Lacalle, Carlos Lugo, Angelina Peñaranda, Inma R. Cantalapiedra
DY 14.4	Wed	11:00–11:30	MA 001	**Synchronization as a mechanism of chaos control; Applications to cardiac arrhythmias.** — •Flavio H. Fenton, Stefan Luther, Philip Bittihn, Daniel Hornung, Eberhard Bodenschatz, Robert F. Gilmour Jr
DY 14.5	Wed	11:30–12:00	MA 001	**Cardiac dynamics from a nonlinear system's perspective - from basic science to applications** — •Stefan Luther

Invited talks of the joint focus session Alternative Energies (with DF)

Organised by Joachim Peinke and Martin Diestelhorst

DF 17.1	Thu	15:00–15:30	EB 107	**Wind energy - Characterization and modeling of short-term fluctuations in incoming wind and power output** — •Michael Hölling, Matthias Wächter, Allan Morales, Patrick Milan, Joachim Peinke
DF 17.2	Thu	15:30–16:00	EB 107	**Fluktuationen in der Stromerzeugung aus erneuerbarer Energien: Ihre Charakterisierung und Möglichkeiten ihrer Kompensation** — •Detlev Heinemann
DF 17.4	Thu	16:30–16:50	EB 107	**The dielectric AC and DC characterisation of composite capacitors for energy storage** — •Sebastian Lemm, Wolfram Münchgesang, Martin Diestelhorst, Mandy Zenkner, Thomas Grossmann, Alexandra Buchsteiner, Horst Beige, Stefan G. Ebbinghaus, Hartmut S. Leipner
DF 17.5	Thu	16:50–17:10	EB 107	**Permittivity, energy density and carrier storage time of film composite capacitors** — •Wolfram Münchgesang, Sebastian Lemm, Martin Diestelhorst, Claudia Ehrhardt, Jens Glenneberg, Alexandra Buchsteiner, Horst Beige, Stefan G. Ebbinghaus, Hartmut S. Leipner
DF 17.6	Thu	17:10–17:40	EB 107	**High Tc Superconducting Energy Storage Systems** — •Frank Werfel
DF 17.7	Thu	17:40–18:10	EB 107	**The transmission of high-power microwaves via dielectric diamond windows: Design, qualification and first steps towards a broadband diamond window in the range of 30GHz to several THz for actual and future fusion devices** — •Theo Scherer, Dirk Strauss

Invited talks of the symposium SYNM

See SYNM for the full program of the symposium.

SYNM 1.1	Wed	15:00–15:30	H 0105	**Mechanical resonators in the quantum regime** — •Andrew N. Cleland

SYNM 1.2	Wed	15:30–16:00	H 0105	**Quantum optomechanics: exploring the interface between quantum physics and gravity** — •Markus Aspelmeyer
SYNM 1.3	Wed	16:00–16:30	H 0105	**Integrated transduction and coherent control of high Q nanomechanical systems using dielectric gradient forces** — •Eva M. Weig
SYNM 1.4	Wed	16:30–17:00	H 0105	**Cavity optomechanics with microwave photons** — •John Teufel
SYNM 1.5	Wed	17:00–17:30	H 0105	**Optomechanical crystals** — •Oskar Painter

Invited talks of the symposium SYND

See SYND for the full program of the symposium.

SYND 1.1	Thu	9:30–10:00	H 0105	**Controlling Complex Networks with Compensatory Perturbations** — •Adilson E. Motter
SYND 1.2	Thu	10:00–10:30	H 0105	**Toward control, prediction, and optimization of biological and engineering complex networks** — •Kazuyuki Aihara
SYND 1.3	Thu	10:30–11:00	H 0105	**Design of robust functional networks as complex combinatorial optimization problem** — •Alexander S. Mikhailov
SYND 1.4	Thu	11:00–11:30	H 0105	**Braess Paradox, (In-)Stability and Optimal Design: Nonlinear Dynamics of Modern Power Grids** — •Marc Timme, Dirk Witthaut, Martin Rohden, Andreas Sorge
SYND 1.5	Thu	11:30–12:00	H 0105	**Delay-Coupled Laser Networks: Complex Behavior, Synchronization and Applications** — •Ingo Fischer

Invited talks of the symposium SYOL

See SYOL for the full program of the symposium.

SYOL 1.1	Fri	9:30–10:00	H 0105	**From sequence to function: Random polymerization and modular evolution of RNA** — •Susanna C. Manrubia
SYOL 1.2	Fri	10:00–10:30	H 0105	**Spontaneous autocatalysis and periodic switching in a prebiotic broth** — •Eva Wollrab, Sabrina Scherer, Karsten Kruse, Albrecht Ott
SYOL 1.3	Fri	10:30–11:00	H 0105	**Thermal solutions for molecular evolution** — •Dieter Braun
SYOL 1.4	Fri	11:00–11:30	H 0105	**Systems chemistry: Self-replication and chiral symmetry breaking** — •Guenter von Kiedrowski

Sessions

DY 1.1–1.14	Mon	9:30–13:15	MA 001	**Statistical Physics of Biological Systems I (with BP, talks from DY)**
DY 2.1–2.10	Mon	9:30–12:45	MA 004	**Statistical Physics (General)**
DY 3.1–3.8	Mon	10:00–12:00	MA 144	**Fluid dynamics I**
DY 4.1–4.11	Mon	15:00–18:15	MA 001	**Quantum Dynamics, Decoherence, and Quantum Information**
DY 5.1–5.9	Mon	15:00–17:30	MA 004	**Soft Matter I**
DY 6.1–6.6	Mon	15:00–16:30	MA 144	**Delay Dynamics**
DY 7.1–7.7	Mon	16:45–18:30	MA 144	**Reaction-Diffusion-Systems**
DY 8.1–8.8	Mon	15:00–17:30	C 243	**Glasses I (with CPP, talks by CPP)**
DY 9.1–9.10	Mon	15:00–17:30	H 1058	**Statistical Physics of Biological Systems II (with BP, talks from BP)**
DY 10.1–10.13	Tue	9:30–13:00	MA 001	**Nonlinear Dynamics, Synchronisation and Chaos**
DY 11.1–11.10	Tue	10:00–12:30	MA 004	**Glasses II (with CPP, talks by DY)**
DY 12.1–12.11	Tue	9:30–13:30	H 1028	**Joint focus session (with BP): Statistics of Cellular Motion**
DY 13.1–13.4	Tue	14:15–15:15	MA 004	**Nonlinear Stochastic Processes**
DY 14.1–14.5	Wed	9:30–12:00	MA 001	**Joint focus session: Nonlinear Dynamics of the Heart**
DY 15.1–15.13	Wed	9:30–13:30	MA 004	**Statistical Physics far from equilibrium**
DY 16.1–16.7	Wed	10:00–12:00	MA 144	**Fluid dynamics and turbulence II**
DY 17.1–17.1	Wed	9:30–10:15	H 0110	**Networks I (with SOE)**
DY 18.1–18.9	Wed	10:15–12:45	H 0110	**Networks II (with SOE)**
DY 19.1–19.7	Wed	15:00–16:45	MA 001	**Nonlinear Dynamics of the Heart: Contributed talks to focus session**
DY 20.1–20.7	Wed	15:00–16:45	MA 004	**Networks III**

DY 21.1–21.10	Wed	14:30–17:15	MA 144	**Granular Matter/Contact Dynamics**
DY 22.1–22.53	Wed	17:00–19:00	Poster A	**Posters I**
DY 23.1–23.7	Thu	9:30–11:15	MA 001	**Quantum Chaos I**
DY 24.1–24.7	Thu	11:30–13:15	MA 001	**Quantum Chaos II**
DY 25.1–25.13	Thu	9:30–13:30	MA 004	**Brownian Motion and Transport**
DY 26.1–26.7	Thu	15:00–18:10	EB 107	**Joint focus session: Alternative Energies: Compensation of long- and short-term fluctuations (with DF)**
DY 27.1–27.10	Thu	14:30–17:15	MA 004	**Transport and Anomalous Diffusion**
DY 28.1–28.10	Thu	15:00–17:45	MA 144	**Data Analysis Methods and Modelling of Geophysical Systems**
DY 29.1–29.54	Thu	17:00–19:00	Poster A	**Posters II**
DY 30.1–30.8	Fri	10:00–12:00	MA 001	**Networks IV (with SOE)**
DY 31.1–31.13	Fri	9:30–13:30	MA 004	**Phase Transitions and Critical Phenomena**
DY 32.1–32.10	Fri	10:00–12:30	MA 144	**Soft Matter II**

Annual General Meeting of the Dynamics and Statistical Physics Division

Thursday 19:00–20:00 Raum MA 004

- Bericht
- Wahl
- Verschiedenes

DY 1: Statistical Physics of Biological Systems I (with BP, talks from DY)

Time: Monday 9:30–13:15 Location: MA 001

DY 1.1 Mon 9:30 MA 001

On various types of synchronization in networks of coupled neurons — •Philipp Hövel[1,2], Alexander Fengler[1], Alexander Heesing[1], and Eckehard Schöll[1] — [1]Technische Universität Berlin, Germany — [2]Bernstein Center for Computational Neuroscience Berlin, Germany

Research on complex networks continues to receive more and more attention since the last decades both from a data-driven and dynamics-driven perspective. In the latter case, collective and cooperative dynamics of coupled systems forms a central phenomenon that is of large interest in various fields. These range from social science and economics to biology, physics, and neuroscience and beyond.

In our contribution, we discuss the synchronization of coupled integrate-and-fire neurons with partial reset in various network topologies. These include all-to-all, ring, and scale-free networks. We find a transition from complete synchronization via cluster synchronization to desynchronization in dependence upon the reset parameter. Our results are based on numerical simulations, which we complement by analytical considerations.

DY 1.2 Mon 9:45 MA 001

Complex activation patterns in a simple deterministic model of excitable neural networks — •Guadalupe C. Garcia[1], Claus C. Hilgetag[2], and Marc Thorsten Hütt[1] — [1]School of Engineering and Science, Jacobs University, Bremen, Germany — [2]University Medical Center Eppendorf, Hamburg University, Hamburg, Germany

Understanding the interplay of topology and dynamics of excitable neural networks is one of the major challenges in computational neuroscience. Here we employ a simple deterministic model of excitation propagation to explore how network-wide activation patterns are shaped by neural network architecture.

The model consists of three discrete states for each node (susceptible S, excited E, refractory R), which are updated synchronously in discrete time steps according to a set of update rules allowing for signal propagation. In particular, an element returns to the susceptible state after r time steps. For small r, the network dynamics settle into an regular oscillatory behavior after a transient period. The set of nodes is thus partitioned into distinct groups of nodes, where two nodes are in the same group when they are simultaneously excited.

Two questions about this process are at the core of our investigation: (1) How does the dynamic partitioning into groups depend on network architecture (investigated by averaging the groupings over many different initial conditions)? (2) How does the length of the transient depend on network architecture? By exploring these deterministic excitation dynamics we aim at better understanding, which topological features facilitate self-sustained activity of neural networks.

DY 1.3 Mon 10:00 MA 001

Dynamics of inhomogeneous neural systems with nonlocal coupling — •Iryna Omelchenko[1,2], Philipp Hövel[1,2], and Eckehard Schöll[1] — [1]Technische Universität Berlin, Germany — [2]Bernstein Center for Computational Neuroscience Berlin, Germany

We investigate the cooperative dynamics of nonlocally coupled neural populations modeled by FitzHugh-Nagumo systems, which is a generic model for type-II excitability. The individual systems are considered to operate above a Hopf bifurcation, that is, they display oscillatory local dynamics. Furthermore, inhomogeneity of the local elements is introduced in the system via a distribution of threshold parameters. Varying the coupling parameters, i.e., coupling radius and strength, and in dependence on the inhomogeneous system's parameter distribution, we analyze spatio-temporal dynamics in the system. Coherent solutions, their stability and mechanisms of transition from coherence to incoherence are analyzed. Especially, we discuss the occurrence of chimera states that exhibit spatial coexistence of regular synchronized and irregular spatially incoherent regions.

DY 1.4 Mon 10:15 MA 001

Spiral-wave prediction in a lattice of FitzHugh-Nagumo oscillators — •Miriam Grace and Marc-Thorsten Hütt — Jacobs University Bremen, Bremen, Germany

In many biological systems, variability of the components can be expected to outrank statistical fluctuations in the shaping of self-organized patterns. The distribution of single-element properties should thus allow the prediction of features of such patterns. In a series of previous studies on established computational models of *Dictyostelium discoideum* pattern formation we demonstrated that the initial properties of potentially very few cells cells have a driving influence on the resulting asymptotic collective state of the colony [1,2]. One plausible biological mechanism for the generation of variability in cell properties and of spiral wave patterns is the concept of a "developmental path", where cells gradually move on a trajectory through parameter space. Here we review the current state of knowledge of spiral-wave prediction in excitable systems and present a new one-dimensional developmental path based on the FitzHugh-Nagumo model, incorporating parameter drift and concomitant variability in the distribution of cells embarking on this path, which gives rise to stable spiral waves. Such a generic model of spiral wave predictability allows new insights into the relationship between biological variability and features of the resulting spatiotemporal pattern.

[1] Geberth, D. and Hütt, M.-Th. (2008). Phys. Rev. E 78, 031917.
[2] Geberth, D. and Hütt, M.-Th. (2009). PLoS Computational Biology 5, e1000422.

DY 1.5 Mon 10:30 MA 001

Spatio-temporal dynamics of bumblebees foraging under predation risk — Friedrich Lenz[1], Thomas C. Ings[2], Lars Chittka[2], Aleksei V. Chechkin[3], and •Rainer Klages[1] — [1]Queen Mary University of London, School of Mathematical Sciences, UK — [2]Queen Mary University of London, School of Biological and Chemical Sciences, UK — [3]Inst, f. Theor. Physics, NSC KIPT, Kharkov, Ukraine

We study bumblebees searching for nectar in a laboratory experiment with and without different types of artificial spiders as predators. We find that the flight velocities obey mixed probability distributions reflecting the access to the food sources while the threat posed by the spiders shows up only in the velocity correlations. This means that the bumblebees adjust their flight patterns spatially to the environment and temporally to predation risk. Key information on response to environmental changes is thus contained in temporal correlation functions and not in spatial distributions.

[1] preprint arXiv:1108.1278 (2011)

DY 1.6 Mon 10:45 MA 001

Fluctuation-sensitive coarse-graining for stochastic dynamics — •Bernhard Altaner and Jürgen Vollmer — Max Planck Institut für Dynamik und Selbstorganisation, Göttingen

We consider Markov processes on a finite state space. Such stochastic processes can be viewed as a random walk on a network. Physically, the states represent a mesoscopic description as they summarize regions of phase space of an underlying microscopic dynamics. For non-equilibrium steady states, probability conservation gives rise to cyclic dynamics. Cycles connect the stochastic, mesoscopic description to the thermodynamic, macroscopic description. Here, we present a method for complexity reduction of the mesoscopic dynamics is where the new stochastic dynamics preserves the most important connections to the other scales. As an example, we consider the stochastic dynamics of the molecular motor protein kinesin.

DY 1.7 Mon 11:00 MA 001

The role of diffusion in the SIRS epidemic model — Fernando Peruani[1] and •Chiu Fan Lee[2] — [1]Lab. J.A.Dieudonné, Université de Nice - Sophia Antipolis — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

In the well-mixed limit of the classical SIRS epidemic model, an initial epidemic outbreak will persist if the basic reproductive number is larger than 1. This quantity indicates the number of secondary cases caused by an infected individual and is believed to depend exclusively on the parameters relevant to the spreading of the disease. If the individuals in the system also diffuse, it is unclear how this epidemic threshold will be affected. In this work, we perform extensive lattice-based simulations to demonstrate that the epidemic threshold and the average number of infected individuals are in fact strongly affected by the diffusion coefficient, D, exhibited by the agents. We then support our numerical results with field-theoretic analysis.

15 min, break

DY 1.8 Mon 11:30 MA 001

Generalized Entropies for Clustering, e.g., in Molecular Evolution — •Kay Hamacher — TU Darmstadt, 64287 Darmstadt, Germany

Entropy is a key concept in information theory. Analysis of empirical data is often improved by relying on (relative) entropies. In this talk I want to describe current progress in clustering approaches by optimization techniques [1-2] applied to entropy distances via generalized entropy concepts [3], in phylogenies [4,5], finite-size effects in empirical data [6], and in molecular design [7].

[1] K. Hamacher. J.Comp.Phys., 227(2):1500-1509, 2007
[2] K. Hamacher. Europhys.Lett. 74(6):944, 2006
[3] R. Bose, G. Thiel, K. Hamacher. Variation in Local Entropy to Cluster Genomic Sequences, submitted, 2011.
[4] K. Hamacher. Proc. of BIOINFORMATICS 2010, p. 114-122, A. Fred, J. Filipe, H. Gamboa (eds.), ISBN 978-989-674-019-1
[5] K. Hamacher, Information Theoretical Dissection of the Holobiont - Host-Virus Interaction as an Example, Nova Acta Leopoldina, accepted, 2011
[6] P. Weil, F. Hoffgaard, K. Hamacher. Comp. Biol. Chem. 33:440-444, 2009
[7] K. Hamacher. J.Comp.Chem., 28(16):2576-2580, 2007

DY 1.9 Mon 11:45 MA 001

Stochastic description of birth and death processes governed by a mixture of exponential and non-exponential waiting times — •Stephan Eule — Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen

The dynamics of complex biological systems is significantly influenced by fluctuations originating from intrinsic as well as extrinsic sources. In general, the discrete nature of individual events, such as the birth and death of an individual in a population or the production and degradation of molecules in a chemical reaction, is the main source of intrinsic noise. The occurrence of such events is usually modeled by Poissonian statistics, implying that the probability per unit time for an event to happen is assumed to be constant. Many complex systems however exhibit deviations from elementary Poissonian statistics. Such deviations can arise for example in coarse-grained stochastic models of gene expression, where the waiting time distribution can be more general than the simple exponential distribution.

In this contribution we consider birth and death processes which are governed by both, exponential as well as non-exponential waiting times. We derive the corresponding master equation and present methods to approach this equation analytically. As an example we consider a reaction where the production of molecules is governed by a non-exponential waiting time distribution and the degradation follows regular Poissonian statistics.

DY 1.10 Mon 12:00 MA 001

Discriminating the effects of spatial extent and population size in cyclic competition among species — •David Lamouroux[1,2], Stephan Eule[1], Theo Geisel[1,2], and Jan Nagler[1,2] — [1]Max Planck Institute for Dynamics & Self-Organization, Göttingen, Germany — [2]Institute for Nonlinear Dynamics, Department of Physics, Univeristy of Göttingen, Göttingen, Germany

Quantifying and understanding the stability and biodiversity of ecosystems is a major task in biological physics as well as in theoretical ecology. From the perspective of game theory, this is highly relevant for questions pertaining to the emergence of cooperation or the coexistence of cyclically competing species. For the latter, it has recently been shown that the mobility of individuals can support the stability of biodiversity by the formation of spirals. In this contribution, we present a population model for species under cyclic competition that extends earlier lattice models to allow the single cells to accommodate more than one individual by introducing a per cell carrying capacity. We confirm that the emergence of spirals induce a transition from an unstable to a stable regime. This transition however does not appear to be sharp and we find a broad intermediate regime that exhibits an ambiguous behavior. The separation of the two regimes by the usual scaling analysis is thus hampered. The newly introduced carrying capacity offers an alternative way of characterizing the transition. We thus overcome the original limitations by separately analyzing the effect of spatial extent and population size.

DY 1.11 Mon 12:15 MA 001

Modelling of DNA-Hybridization — •Olaf Leidinger and Ludger Santen — Universität des Saarlandes

Bringing together two types of single-stranded DNA molecules (targets: perfect matching and those with one mismatch) in a aqueous solution and one type of surface-attached single-stranded DNA molecules (probes) one can observe hybridization of double stranded DNA molecules. The percentage of perfect matching (PM) strands at the surface is found to be independent of the concentration of those with one mismatch (MM). This dominance is not in agreement with a Langmuir adsorption kinetics in contrast to the adsorption of a single species. We introduce a theoretical approach to the competitive adsorption of DNA strands illustrating the prerequisites for the dominant adsorption of PM DNA strands.

DY 1.12 Mon 12:30 MA 001

A Statistical Analysis of Production in Cells: Flux Distributions, Enzyme Time Scales and Metabolic Network Properties — •Moritz E. Beber and Marc-Thorsten Hütt — School of Engineering and Science, Jacobs University Bremen, Germany

Numerous studies have addressed statistical properties of metabolic systems, both from the perspective of network structure and of dynamical systems. On a genome-wide scale, the considered dynamics were usually metabolic fluxes, i.e., material flow through biochemical reactions, either measured *in vivo* or computed using flux-balance analysis as a proxy for real behaviour.

In this study, we revisit and modify some of the existing results linking topology and dynamics: (1) We integrate timing information about the principal agents of catalysation of biochemical reactions, the enzymes, in a new way. (2) We carefully analyse the interplay of different network properties and re-compute metabolic network motifs, taking into account the fact that metabolic networks are bipartite, modular, layered, and contain different categories of bidirectional links. (3) Using a minimal model of evolved flow networks as a guideline, we explore, which network properties are correlated with metabolic robustness.

Our object of study is the metabolism of *Escherichia coli*. We use a manually curated metabolic network for topological information, a realistic model of its metabolism for flux balance analysis sampling diverse environmental conditions, and information on the mechanics of enzymes from a specialised database.

DY 1.13 Mon 12:45 MA 001

Active microswimmers with spatially varying self-propulsion — •Aljoscha Hahn[1], Giovanni Volpe[2,3], Clemens Bechinger[2,3], and Holger Stark[1] — [1]Technische Universität Berlin, Germany — [2]Max-Planck-Institut für intelligente Systeme, Stuttgart, Germany — [3]Universität Stuttgart, Germany

The statistical physics of active microswimmers, which are capable of propelling themselves through a viscous environment, is intensively investigated at the present time. Recently, Janus particles were studied in a subcritical mixture [1] and it was found that the speed of self-propulsion can be controlled by the strength of illumination. In particular, a spatially varying light intensity induces a spatially varying self-propulsion. Based on the Smoluchowski equation, we study how active particles with a position dependent swimming speed behave and speculate about a novel type of ratchet.

[1] G. Volpe et al, Soft Matter 7, 8810 (2011)

DY 1.14 Mon 13:00 MA 001

Continuous Dynamic Photostimulation - delivering defined, in-vivo-like fluctuating stimuli with Channelrhodopsins — •Andreas Neef[1,3], Achmed El Hady[1,2,3], Walter Stühmer[2,3], and Fred Wolf[1,3] — [1]MPI für Dynamik und Selbstorganisation, Göttingen — [2]MPI für Experimentelle Medizin, Göttingen — [3]BFNT

Central neurons typically operate in a noise driven regime: thousands excitatory and inhibitory synapses give rise to a constantly fluctuating conductance. Its statistic is similar to low-pass filtered white noise conductance that can be parameterized by is average, standard deviation and correlation time. An understanding of action potential (AP) generation and encoding in the noise driven regime requires the detection of AP times during stimulation with defined time dependent conductance. Using a light activated ion channel (ChIEF) under continuously fluctuating illumination, we achieve a defined, reproducible conductance modulation that mimicks the effect of the naturally occurring synaptic inputs. Cultured neurons subjected to this continuous dynamic photostimulation (CoDyPs) generate seemingly random, but reproducible patterns of APs in experiments lasting several hours. The induced conductance waveform can be precisely predicted by convolution of the light signal with the light-conductance transfer function of ChIEF. Together with non-invasive AP detection by extracellular electrodes, CoDyPs lays the foundation for very long-lasting studies of action potential generation in a fluctuation driven regime. This will allow the measurement of dynamical response properties and the respective cut-off frequencies from individual neurons.

DY 2: Statistical Physics (General)

Time: Monday 9:30–12:45 Location: MA 004

Invited Talk DY 2.1 Mon 9:30 MA 004

Separation of chiral particles in micro- and nanofluidic systems — •Ralf Eichhorn — Nordic Institute for Theoretical Physics (Nordita), Stockholm, Sweden

Standard techniques for separating a mixture of chiral molecules (enantiomers) rely on chiral auxiliary substances. We discuss the alternative possibility to sort chiral molecules by their distinct physical behavior in external force fields without making use of additional chiral agents. Using numerical simulations and theoretical arguments, this separation concept is demonstrated for simple model systems, and the basic physical mechanisms are illustrated and analyzed. Furthermore, experimental realizations in microfluidic systems are presented.

DY 2.2 Mon 10:00 MA 004

Kinetics of Nucleation on Surfaces in the Ising model — •Fabian Schmitz, Peter Virnau, and Kurt Binder — Institut für Physik, Johannes Gutenberg-Universität Mainz - Staudingerweg 7, D-55099 Mainz, Germany

We consider homogeneous and heterogeneous nucleation in the 3d Ising model, and compare information gained from nucleation dynamics to free energy computations in the context of classical nucleation theory. To define "physical clusters", the Swendsen-Wang algorithm is applied. We force the system into a metastable state from which it escapes into a stable state via nucleation. In the heterogeneous case, two flat walls with surface fields are introduced on which nuclei grow with some contact angle depending on the surface fields. To extract the critical cluster size, at which clusters decay or grow with equal probability, we measure the average growth rate $R(l)$ of nuclei with size l by monitoring the growth and decay of individual clusters over time for varying bulk and surface magnetic fields. Critical cluster sizes obtained from this method are comparable yet slightly larger than predicted from classical nucleation theory in both homogeneous and heterogeneous nucleation scenarios. The time dependence of the cluster distributions are also in agreement with previous predictions.

DY 2.3 Mon 10:15 MA 004

Explosive condensation in a mass transport model — •Bartlomiej Waclaw and Martin Evans — School of Physics, University of Edinburgh

Recent studies in non-equilibrium statistical physics show that diverse phenomena such as jamming in traffic flow, wealth condensation in macroeconomies or hub formation in complex networks can be understood by the condensation transition, in which a finite fraction of the system mass becomes localized in space. A classical model of condensation is the Zero-Range Process (ZRP) in which particles hop between sites of a 1d lattice with the rate which decreases with the number of particles at the departure site. This causes the condensate to evolve more slowly, the more particles it has. Therefore, the condensate remains static once it has formed, melting and reforming very rarely. In his talk we demonstrate a completely different mechanism of condensation, motivated by processes such as gravitational clustering or formation of droplets in clouds, where aggregation of particles speeds up in time as a result of increasing exchange rate of particles between growing clusters. In our model, particles hop between lattice sites with the rate u(m,n) which increases with the numbers m,n of particles at interacting sites. We show that condensation occurs in this model through a contrasting dynamical mechanism to that previously considered — the formation of the condensate happens on a very fast time scale and we term it explosive.

DY 2.4 Mon 10:30 MA 004

Flexible Rare Event Sampling Harness System — •Kai Kratzer and Axel Arnold — Institute for Computational Physics, Stuttgart, Germany

Many processes in nature can be classified as rare events, e.g. chemical reactions, nucleation of crystals or translocation of DNA through a pore. In all this processes, the time between the occurance of these events is much larger than the temporal duration of the event itself, meaning that practically all the simulation time is spent in waiting for the event. If the system under consideration requires expensive calculations, for example electrostatic interactions, the event will never happen using conventional brute-force simulations.

Recently, several new methods to succeed in this challenge have been put forward, particularly Forward Flux Sampling (FFS) or S-PRES. In this work, we present a flexible framework for simulating rare events using these sampling techniques. Our framework is suitable for simulating quasi-static and dynamic systems in the equilibrium or the non-equilibrium state and uses a plugin-system for the underlying dynamics. At present, it can steer popular MD packages such as GROMACS, ESPResSo, but due to the simple interface of our plugin-system, it is also easy to attach other or self-written code. The system supports farming via standard TCP/IP networking and uses a database for efficient information storage. It is therefore also suited to make use of current parallel high performance hardware.

DY 2.5 Mon 10:45 MA 004

A new method to calculate partition functions — •Klaus Morawetz — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP) Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany

An exact correspondence is established between a N-body classical interacting system and a $N-1$-body quantum system with respect to the partition function. The resulting hermitian quantum-potential is a $N-1$-body one. Inversely the Kelbg potential is reproduced which describes quantum systems at a quasi-classical level. The found correspondence between classical and quantum systems allows also to approximate dense classical many–body systems by lower order quantum perturbation theory replacing Planck's constant properly by temperature and density dependent expressions. As an example the dynamical behavior of an one - component plasma is well reproduced concerning the formation of correlation energy after a disturbance utilizing solely the analytical quantum - Born result for dense degenerated Fermi systems. As further examples the application to spin models is discussed. K. Morawetz; Phys. Rev. E 66 (2001) 022103

15 min. break

DY 2.6 Mon 11:15 MA 004

An extension of the derivative expansion of the exact renormalization group to finite momenta — •Nils Hasselmann — MPI f. Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart

The non-perturbative renormalization group (NPRG) technique is based on an exact fow equation of the effective average action. It has proved especially useful when applied to critical phenomena. While the exact flow equation of the effective average action can almost never be solved, it allows for novel approximation techniques which are indeed non-perturbative. One rather successful approximation strategy is the derivative expansion, where the effective average action is expanded consistently to a given order in spatial derivatives, but no truncation is made in the power of the fields.

Here we present a simple truncation scheme of the exact flow equations for the effective action which allows to access the full momentum structure of vertices while at the same time reproducing the results of a leading order derivative expansion of the action, where local correlations are kept to infinite order in the fields. Different to existing schemes to calculate momentum dependent vertices, in our scheme all approximations are done at the level of the effective action which is generally better than truncating the flow equations of a field expansion. As an example for the feasibility of the technique, we present results for the O(n) model.

DY 2.7 Mon 11:30 MA 004

The Central Limit Theorem in Hierarchical Structures — •René Pfitzner, Pavlin Mavrodiev, Ingo Scholtes, Claudio J. Tessone, and Frank Schweitzer — Chair of Systems Design, ETH Zurich, Switzerland

In statistics the (classical) Central Limit Theorem for independent and identically distributed variables is well known. A generalization of this theorem is the so-called *Lyapunov Central Limit Theorem*, which is applicable to settings with independent, but *not* necessarily identically distributed random variables. In this contribution, we generalize these theorems in a hierarchical setting i.e., the aggregation of random variables is performed in a step-wise fashion where first sub-groups of all variables get aggregated. We show that the non-linearity introduced by the hierarchical organization of the variables leads to an interesting effect: not all the aggregation schemes lead to the same variance at the end of the hierarchy. In fact, there is an optimum hierarchical structure that minimizes the final error, or variance. We pose an optimization problem to find the "most-beneficial" hierarchical scheme for aggregation. We argue that our results have broad implications, ranging from the arrangement of measurements taken with devices with different intrinsic precision, to group decision making.

DY 2.8 Mon 11:45 MA 004

Stochastically driven Preisach models of hysteresis — •Sven Schubert and Günter Radons — Chemnitz University of Technology, 09107 Chemnitz, Germany

The Preisach model is a phenomenological model which is successfully applied to describe hysteretic interrelations of various physical and non-physical origins. Hysteresis involves the development of a memory which is accountable for the multistability present in such systems. It was shown recently [1] that this memory is reflected in long-time tails in the autocorrelation of the response of the Preisach model even for uncorrelated external driving fields. Hence, hysteresis is a mechanism for the generation of 1/f-noise. Using numerical simulations, these rigorous results are extended to models driven by Markovian input processes with finite correlation decay rate and by stochastic processes showing long-term correlations.

One observes that the autocorrelation of the hysteresis response does never decay faster than the autocorrelation of the external driving. We show that the rigorous results on Preisach models with uncorrelated input also hold asymptotically in presence of exponentially decaying input correlations. Furthermore, we show that uncorrelated driving fields can cause a slower correlation decay of the hysteresis response than long-term correlated driving fields.

[1] G. Radons, Phys. Rev. Lett. **100**, 240602 (2008).

DY 2.9 Mon 12:00 MA 004

Study of transistor performance of carbon nanotube networks — Milan Žeželj, •Igor Stanković, and Aleksandar Belić — Institute of Physics Belgrade, Scientific Computing Laboratory

In the random networks of mixed metallic and semiconducting carbon nanotube (CNT) with different chiralities, there is a trade off between high on-current (dense networks) and high on/off current ratio (sparse networks). Monte Carlo simulations were performed to study effects of nanotube/nanotube contact resistance on the on- and off-currents. Using tunneling model we confirm that junction conductance between two CNTs is strongly dependent on the crossing angle. The nanotubes exhibit a peak of conductivity over the different angular ranges depending on their chiralities. We analyze how percolation threshold density of CNTs, conductivity exponents and prefactors depend on the position and width of conductive peak. Furthermore, when network size is comparable to a single CNT length, we find a significant size dependence of the on/off currents and their variance.

Invited Talk DY 2.10 Mon 12:15 MA 004

Melting transition of hard disks — •Werner Krauth — Departement de physique, Ecole normale superieure, Paris, France

The hard-disk model has exerted outstanding influence on computational physics and statistical mechanics. Decades ago, hard disks were the first system to be studied by Markov-chain Monte Carlo methods and by molecular dynamics. It was in hard disks, through numerical simulations, that a two-dimensional melting transition was first seen to occur even though such systems cannot develop long-range crystalline order. Analysis of the system was made difficult by the absence of powerful simulation methods.

In recent years, we have developed a number of powerful Monte Carlo algorithms for hard disks and related systems. I will in particular show how the powerful event-chain Monte Carlo algorithm has allowed us to prove that hard disks melt with a first-order transition from the liquid to the hexatic and a continuous transition from the hexatic to the solid.

DY 3: Fluid dynamics I

Time: Monday 10:00–12:00 Location: MA 144

DY 3.1 Mon 10:00 MA 144

Convection in suspensions at large solutal Rayleigh numbers — •Georg Freund and Walter Zimmermann — Institute of Physics, University of Bayreuth, Germany

We present theoretical results on thermal convection in colloidal suspensions. The dynamics of the suspension is described by a continuum model for binary fluid mixtures with very small values of the Lewis-number. In recent experiments with thermo-sensitive suspensions a rather strong Soret effect has been detected, which leads at moderate temperature differences between the boundaries of the convection cell already to rather large solutal Rayleigh numbers. We give theoretical explanations for the experimentally observed oscillations using low-dimensional models and direct numerical simulations of the full balance equations.

DY 3.2 Mon 10:15 MA 144

Non-linear rheology of active soft matter — •Sebastian Heidenreich[1] and Sabine H. L. Klapp[2] — [1]Physikalisch Technische Bundesanstalt Berlin, Germany — [2]Technische Universität Berlin, Germany

From self-sustained bacterial turbulence to viscosity reduction, active soft matter show amazing non-equilibrium effects and unusual flow behavior. The flow of complex fluids is characterized by its rheological properties as, for example, shear viscosity and normal stress differences. In the presentation, we discuss the response of active particle suspensions or active gels subjected to a shear flow. Using a set of extended hydrodynamic equations we derive a variety of analytical expressions for shear viscosity and normal stress differences. Depending on the nature of activity, the system show shear-thickening and -thinning in qualitative agreement with experiments. Furthermore, predicted changes of normal stress differences are surprising and different compared with passive counterparts.

DY 3.3 Mon 10:30 MA 144

On the dynamics of dimer and trimer suspensions — •Johannes Greber and Walter Zimmermann — Uni Bayreuth, LS Theoretische Physik I

The nonlinear hydrodynamic interaction between dumbbells and longer chains of beads coupled via harmonic spring forces in suspension causes in linear shear flow a much more complex dynamics, as obtained for a single dumbbell or chain. This result is obtained with Fluid Particle Dynamics (FPD) simulations of such suspensions. The complex flow field caused by the dynamics of dumbbells and chains as well as the mixing behavior is compared with those obtained in inertial turbulence at high Reynolds numbers. The complex dumbbell dynamics shares also similarities with so called elastic turublence, observed in experiments with polymer solutions [1].

[1] A. Groisman, V. Steinberg : New J. Phys. (2004) *Elastic turbulence in curvilinear flows of polymer solutions*

DY 3.4 Mon 10:45 MA 144

Faraday wave patterns under excitation with time reversed asymmetric periodic wave forms — •Thomas John, Dirk

Pietschmann, and Ralf Stannarius — Institut für Experimentelle Physik, Fakultät für Naturwissenschaften, Universität Magdeburg, Universitätsplatz 2, D-39106 Magdeburg, Germany

A vertically shaken (periodically exited) Newtonian liquid layer, called Faraday experiment, is a paradigm for pattern forming systems. We investigate experimentally and numerically the onset parameters and wavelengths of the Faraday wave pattern under excitation with temporally asymmetric waveforms. A superposition of two sine waves with a mutual phase shift is used as excitation. Certain phase shifts give the possibility to generate time reversed shapes of the waveforms, in what we focus on here. The measurements are compared with numerical calculations based on the linear stability analysis of the full set of hydrodynamic equations for Newtonian liquids. We demonstrate with a modified Mathieu-equation the astonishing fact: already a linear system can be sensitive to the direction of the asymmetric, periodic excitation in terms of different thresholds amplitudes.

DY 3.5 Mon 11:00 MA 144

Friction controlled bending sheets toward 3D-cylindrical helical tubes — •Nebojša Ćasić and Thomas M. Fischer — Institut für Experimentalphysik V, Universität Bayreuth, Bayreuth, Germany

We study the conformational transition of an ensemble of magnetic particles from linear sheets to a compact 3D-cylindrical helical tubes when subjected to an external magnetic field modulation. We measure the variation of the "pitch" of this helical tubes when they are subjected to different frequency of the magnetic field. We show that for a constant magnetic field ratio system will make a transition from synchronous to asynchronous mode.

DY 3.6 Mon 11:15 MA 144

Receding a plate from a bath: The transition from precursor films to Landau-Levich films — •Mariano Galvagno, Hender López, and Uwe Thiele — Department of Mathematical Sciences, Loughborough University, Loughborough LE11 3TU, UK

In several types of coating processes a solid substrate is removed at a controlled velocity U from a liquid bath. The shape of the liquid meniscus and the thickness of the coating layer depend on U. These dependencies have to be understood in detail for non-volatile liquids to control the deposition of such a liquid and to lay the basis for the control in more complicated cases (volatile pure liquid, solution with volatile solvent).

We study the case of non-volatile liquids employing a precursor film model that describes partial wettability with a Derjaguin (or disjoining) pressure. In particular, we focus on the relation of the deposition of (i) an ultrathin precursor film at small velocities and (ii) a macroscopic film of thickness $h \sim U^{2/3}$ (corresponding to the classical Landau-Levich film).

Depending on the plate inclination, four regimes are found for the change from case (i) to (ii). The different regimes and the transitions between them are analysed employing numerical continuation of steady states and saddle-node bifurcations and simulations in time. We discuss the relation of our results to results obtained with a slip model [J. Ziegler, J. H. Snoeijer and J. Eggers, *J. Eur. Phys. J. Special Topics* **166**, 177 (2009)].

We acknowledge support by the EU (PITN-GA-2008-214919).

DY 3.7 Mon 11:30 MA 144

Development of Surface Waviness during Pulsed Electron Beam Treatment — •Renate Fetzer, Wladimir An, Georg Mueller, and Alfons Weisenburger — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Pulsed high-current electron beams have shown their capability to improve surface properties such as hardness, wear, or corrosion resistance of metals and alloys without affecting the bulk material. The interaction of the electron beam with a metal target leads to rapid heating and cooling of the surface layer, accompanied by different phase transitions between the solid, liquid, vapor, and plasma phase. As a consequence of the treatment, however, a topographical pattern evolves on the target surface and is conserved upon re-solidification. This waviness can reach typical amplitudes in the range of tens of micrometers, which is disadvantageous for some applications.

In this work, we present a systematic study on the development of surface waviness during pulsed high-current electron beam irradiation, including time- and space-resolved diagnostics during treatment and target analysis after treatment. The experimental studies are accompanied by heat conduction simulations. Possible mechanisms of waviness evolution such as cratering due to substrate inhomogeneity and various hydrodynamic instabilities are discussed.

DY 3.8 Mon 11:45 MA 144

Impact of micrometer droplets on free-standing fluid films — •Sarah Dölle, Thomas John, Alexey Eremin, and Ralf Stannarius — Abteilung Nichtlineare Phänomene, Otto-von-Guericke-Universität Magdebrug, Deutschland

Smectic liquid crystals can form homogeneous free-standing fluid films. With a thickness on the order nanometers and lateral extensions up to several centimeters, they are unique systems to study fluid dynamics in two dimensions. Picoliter droplets of water are shot on these films with a microdispenser. Via high speed imaging, we investigate the impact of the droplets on curved and planar films, and the subsequent shape changes. Capillary forces and surface effects play the major roles for the equilibration of the droplet. Additionally, one has to take into account the elastic forces of the liquid crystal due to the molecular layer order.

DY 4: Quantum Dynamics, Decoherence, and Quantum Information

Time: Monday 15:00–18:15 Location: MA 001

DY 4.1 Mon 15:00 MA 001

Langevin trajectories deriving from quantum histories — •Hendrik Niemeyer and Jochen Gemmer — Universität Osnabrück, Barbarastraße 7, D-49069 Osnabrück

Our point of departure is the Pauli master equation and its conceptual framework. According to the latter a "property" of a system such as a particle being in a certain region in space or two macroscopic objects featuring a certain temperature difference, etc. corresponds to a (projective) subspace of full Hilbert space. The Pauli master equation suggests transitions between these quantitiative properties (which we choose to call "mesostates") with rates given by Fermis Golden Rule. We show that assuming such rates as well as Gaussian scaling of the dimension of the above subspace with the mesostate and an exponential relaxation of the average mesostate neccessarily yields Langevin-type stochastic dynamics for the mesostate. From a purely quantum perspective the Langevin trajectories then correspond to quantum consistent and markovian histories.

DY 4.2 Mon 15:15 MA 001

Survival probabilities of energy transfer in random networks — •Anastasiia Anishchenko, Alexander Blumen, and Oliver Mülken — Universität Freiburg, Physikalisches Institut, Hermann-Herder-str. 3, Freiburg im Breisgau, Germany

Recently, the dynamics of excitations in, e.g., ultra-cold Rydberg gases or in light-harvesting complexes, both of which can be modelled by networks, have been of particular interest. Here, the initial excitation (a Frenkel exciton) is created by absorbing a laser excitation or by capturing solar photons. The exciton is transported over the network until it encounters sites where it can get absorbed (the reaction center in the light-harvesting complexes). This process can be modelled by non-hermitian Hamiltonians having complex eigenvalues [1]. In the following, we study (ensemble-averaged) random networks in which the excitation can vanish only at certain (trap) nodes and investigate the survival probability that the exciton does not get trapped during the (quantum) walk over the network. We further show how this is related to the distribution of the imaginary parts of the eigenvalues of the Hamiltonian [2].

[1] O. Mülken, A. Blumen, Phys. Rep. 502, 37 (2011).
[2] A. Anishchenko, A. Blumen, O. Mülken, in preparation.

DY 4.3 Mon 15:30 MA 001

Counting statistics of collective photon transmissions — •Malte Vogl, Gernot Schaller, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin,Berlin

We theoretically study cooperative effects in the steady-state transmission of photons through a medium of N radiators. Using methods from quantum transport, we find a cross-over in scaling from N to N^2 in the current and to even higher powers of N in the higher cumulants of the photon counting statistics as a function of the tunable source occupation. The effect should be observable for atoms confined within a nano-cell with a pumped optical cavity as photon source.

Ref.: Annals of Physics 326 (2011) 2827

DY 4.4 Mon 15:45 MA 001

Entanglement properties of conditional states — •Juan-Diego Urbina[1] and Carlos Viviescas[2] — [1]University of Regensburg, Germany — [2]National University, Colombia

We present a rigorous mathematical result for the amount of multipartite entanglement in conditional states of open quantum systems just after the state of their bosonic environment is measured.

Our main result is a closed formula providing a scaling relation between the probability distribution of experimental outcomes and the amount of entanglement in the state of the central system.

We use this connection to study the distribution of entanglement over the physical ensemble of experimental outcomes, and briefly discuss other consequences of the scaling formula.

DY 4.5 Mon 16:00 MA 001

Dynamics in open systems - from assisted to impeded transport — Petrus Schijven, Alexander Blumen, and •Oliver Mülken — Institute of Physics, University of Freiburg, Germany

We study the dynamics of excitons in molecular aggregates, such as, e.g., photosynthetic complexes or J-aggregates. The dynamics will be modeled by the so-called quantum stochastic walk (QSW) which allows - on a phenomenological level - to interpolate between purely coherent (quantal) transport and purely incoherent (diffusive) transport. Here, the quantum system with a given Hamiltonian is coupled to an environment which we assume to induce diffusive behavior (derived from Fermis golden rule). By introducing excition sources and drains (traps) for the exciton, we show the importance of the initial preparation for, say, transport efficiency measures such as the expected survival time of the exciton [1]. For a given system, a suitable choice of the initial preparation allows to enhance or impede the transport.

[1] P. Schijven, A. Blumen, and O. Mülken, in preparation (2012)

15 min. break

DY 4.6 Mon 16:30 MA 001

Universal Quantum Computing with Spin and Valley Qubits — •Niklas Rohling and Guido Burkard — Department of Physics, University of Konstanz, D-78457 Konstanz, Germany

We study theoretically how to perform state preparation (a), universal quantum gates (b), and read-out (c) in a two-electron double quantum dot with spin and valley degrees of freedom as they are present in graphene or carbon nanotubes. In the spin-only case, task (b) can be implemented via Heisenberg-exchange coupling and local gates [1] and the tasks (a) and (c) by adiabatic transitions between (0,2)- and (1,1)-charge configurations [2]. If valley degeneracy is present, we can consider all states with symmetric charge distribution as a 16-dimensional logic space consisting of two spin and two valley qubits. We show that, although the exchange interaction couples spins as well as valleys, this exchange coupling together with local gates is sufficient to generate a unitary operation which is a universal two-qubit gate in spin space and does not change the valley qubits, or vice versa. State preparation and projective measurements on a specific state are possible by obtaining control of the spin and the valley Zeeman term in each dot.

[1] D. Loss and D. P. DiVincenzo, Phys. Rev. A **57**, 120 (1998)

[2] J. R. Petta et al., Science **309**, 2180 (2005)

DY 4.7 Mon 16:45 MA 001

Non-equilibrium Quantum Phase Transitions in the Dicke Model — •Victor Manuel Bastidas Valencia, Clive Emary, Benjamin Regler, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We establish a set of non-equilibrium quantum phase transitions in the Dicke model by considering a monochromatic non-adiabatic modulation of the atom-field coupling. For weak driving the system exhibits a set of side-bands which allow the circumvention of the no-go theorem which otherwise forbids the occurence of superradiant phase transitions. At strong driving we show that the system exhibits a rich multistable structure and exhibits both first- and second-order non-equilibrium quantum phase transitions.

DY 4.8 Mon 17:00 MA 001

Noise-induced Förster Resonant Energy Transfer between orthogonal dipoles — •Peter Nalbach[1], Igor Pugliesi[2], and Michael Thorwart[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany — [2]II. Lehrstuhl für BioMolekulare Optik, Ludwig-Maximilians-Universität München, Oettingenstraße 67, 80538 Munich, Germany

We show that Förster resonance energy transfer (FRET) in an orthogonally arranged donor-acceptor pair can be induced by environmental noise although direct transfer is prohibited. Environmental fluctuations break the strict orthogonal arrangement of the dipoles and cause effective fluctuating excitonic interactions. Using a scaling argument, we show that interaction fluctuations are coupled to those of the energy levels and are strong enough to induce large FRET rates. This mechanism also explains their temperature dependence observed in a recent experiment on a perylene bisimide dyad and predicts a modified distance dependence as compared to standard Förster theory.

DY 4.9 Mon 17:15 MA 001

Exciton transfer dynamics and quantumness of energy transfer in the Fenna-Matthews-Olson complex — •Peter Nalbach[1], Daniel Braun[2], and Michael Thorwart[1] — [1]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg, Germany — [2]Laboratoire de Physique Théorique, Université Paul Sabatier, 118, route de Narbonne, 31062 Toulouse, France

We present numerically exact results for the quantum coherent energy transfer in the Fenna-Matthews-Olson molecular aggregate under realistic physiological conditions, including vibrational fluctuations of the protein and the pigments for an experimentally determined fluctuation spectrum. We find coherence times shorter than observed experimentally. Furthermore we determine the energy transfer current and quantify its “quantumness” as the distance of the density matrix to the classical pointer states for the energy current operator. Most importantly, we find that the energy transfer happens through a “Schrödinger-cat” like superposition of energy current pointer states.

DY 4.10 Mon 17:30 MA 001

Phase transitions and dark-state physics in two-color superradiance — •Mathias Hayn, Clive Emary, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin

We theoretically study an extension of the Dicke model, where the single-particle Hamiltonian has three energy levels in Lambda configuration (i.e., the excited state is coupled to two nondegenerate ground states via two independent quantized light fields). The corresponding many-body Hamiltonian can be diagonalized in the thermodynamic limit with the help of a generalized Holstein-Primakoff transformation. Analyzing the ground-state energy and the excitation energies, we identify one normal and two superradiant phases, separated by phase transitions of both first and second oder. A phase with both superradiant states coexisting is not stable. In addition, in the limit of two degenerate ground states a dark state emerges, which seems to be analogous to the dark state appearing in the well-known stimulated Raman adiabatic passage scheme.

[1] M. Hayn, C. Emary, and T. Brandes, Phys. Rev. A 84, 053856 (2011)

Invited Talk DY 4.11 Mon 17:45 MA 001

Environment-induced heating in composite quantum systems — •Almut Beige — The School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, United Kingdom

It is emphasized that repeated energy-absorbing measurements on a single component of a composite quantum system can result in a significant amount of heating. In quantum optical systems, this heating might manifest itself for example as a non-zero stationary state photon emission rate – even in the absence of external driving. The underlying energy concentrating mechanism might not be present, when a two-level atom interacts with a free radiation field and a photon-absorbing environment [1]. Nevertheless, it might play a crucial role in sonoluminescence experiments [2].

[1] Extending the validity range of quantum optical master equa-

tions, A. Stokes, A. Kurcz, T. P. Spiller, and A. Beige, arXiv:1111.7206 (2012).

[2] Sonoluminescence and quantum optical heating, A. Kurcz, A. Capolupo, and A. Beige, New J. Phys. 11, 053001 (2009).

DY 5: Soft Matter I

Time: Monday 15:00–17:30 Location: MA 004

DY 5.1 Mon 15:00 MA 004

Onset of flow in a confined model colloidal glass — •Pinaki Chaudhuri[1,2] and Juergen Horbach[1] — [1]Institut für Theoretische Physik II, Heinrich Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, 55099 Mainz, Germany

Understanding the mechanisms that build up flow in soft glassy systems remains an outstanding problem. In recent times, because of various practical applications, flow of such systems under confinement has also drawn considerable attention. Using numerical simulations, we study the onset of flow, under confinement, in a model colloidal glass under an externally applied stress. Typically, amorphous systems yield when the stress exceeds a threshold value (the yield stress) - we show that the time-scales for the onset of steady state flow rapidly increase as the applied stress is lowered towards the threshold. Moreover we observe that, in confinement, these time-scales depend on the nature of the imposed stress - e.g, they are longer for a Poiseuille flow, compared to a Couette flow. We further elucidate the microscopic process that are responsible for these increasing time-scales as well as the differences with the various applied stress fields.

DY 5.2 Mon 15:15 MA 004

Capillary wave analysis of crystal-liquid interface in colloidal model systems — •Aleksandar Mijailovic, Roberto E. Rozas, Jürgen Horbach, and Hartmut Löwen — Institut für Theoretische Physik 2, Heinrich-Heine Universität Düsseldorf, Germany

The properties of the crystal-liquid interface of inhomogeneous colloidal systems is determined from molecular dynamic (MD) simulations. Interactions between particles are modeled by the Yukawa pair potential. As a test of consistency of the capillary waves theory (CWT) the interfacial stiffness is calculated for the (100) crystal orientation using two independent methods: (1) from the spectrum of capillary waves at the interface and (2) from the interfacial broadening-effect predicted by the theory [1, 2]. A complete mapping of the interfacial energy as a function of the crystal orientation from the spectrum of height-height correlation of different crystal orientations is obtained. The results obtained in appropriate units are comparable to the hard spheres case. In addition, the kinetic growth coefficients are estimated in growth simulations of different undercoolings.

DY 5.3 Mon 15:30 MA 004

Orientational dynamics of nematic liquid crystals under shear flow: Stability and growth of dynamical modes in inhomogeneous systems. — •David A. Strehober and Sabine H. L. Klapp — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We study the nonequilibrium dynamics of rodlike nematic polymers under shear flow. We employ a mesoscopic description, and use the alignment tensor as an order parameter. Five coupled partial differential equations describe the dynamics of the alignment tensor [1][2]. The rheological phase diagram with respect to the shear rate and reduced temperature are investigated for the homogeneous case. We employ numerical continuation methods [3], to obtain the boundaries between different dynamic states. We also check the validity of the results for the 1D inhomogeneous case and discuss differences to the homogeneous case. We conclude the talk with results of the investigation of domain growth of dynamic states.

[1] S. Hess, Z.Naturforsch. A **31a**, 1034 (1976)
[2] S. Grandner, S. Heidenreich, S. Hess and S. H. L. Klapp, Eur.Phys.J. E **24**, 353 (2007)
[3] A. Dhooge, W. Govaerts, and Yu. A. Kuznetsov., ACM Trans. Math. Softw. **29**, (2003)

DY 5.4 Mon 15:45 MA 004

Crosslinker-induced formation of filament networks: Dependence on the filament length. — •Thomas Gruhn[1] and Raghunath Chelakkot[2] — [1]Material- und Prozesssimulation, Universität Bayreuth, D-95440 Bayreuth. — [2]Physics Department, Brandeis University, Waltham, MA-02454, USA.

Self-assembling networks of rod-like filaments are of technological and scientific interest. Due to their complex morphology and their huge internal surface area, they are excellently suited for nano-circuits, high efficiency catalysts, and molecular sensors. In the cytoskeleton of living cells, such networks are formed by F-actin filaments, which are interconnected by crosslinkers like myosin or α-actinin. We have analyzed the percolation behavior of a self-assembling network of rigid filaments and reversibly binding crosslinkers with the help of Monte Carlo simulations. In the system, filaments are represented by long spherocylinders, while crosslinkers are mimicked by short spherocylinders with adhesive sites at both ends with which the crosslinkers can bind to the filaments. In our recent studies we have studied the influence of the filament length on the percolation threshold. For a given filament volume fraction and crosslinker filament ratio, the network formation and the percolation threshold is remarkably independent of the filament length, while changes of the packing fraction have a distinct impact on the percolation threshold. The system behavior is analyzed with an analytical approach, which reproduces the binding probability qualitatively and provides a deeper insight into the basic aspects of network formation.

DY 5.5 Mon 16:00 MA 004

Dilatational yielding of solid Langmuir monolayers — •Saeedeh Aliaskarisohi[1], Thomas.M Fischer[1], and Natalia Wilke[2] — [1]University of Bayreuth,Bayreuth, Germany — [2]Universidad Nacional de Cordoba,Cordoba, Argentina

In a previous work, Muruganathan and Fischer observed laser induced local collapse of a methyl stearate monolayer. These experiments opened the possibility of studying the collapse mechanism in a highly controlled manner, since the laser intensity can be easily varied and collapse happens in a definite place (the laser focus). In this paper we extended the work presented by Muruganathan et al., describing the local yielding as an alternative pathway toward monolayer collapse competing with the global collapse of the monolayer. We first corroborated that the laser-induced collapse is a thermocapillary effect and afterward determined the threshold laser power necessary for the local pathway to win over the global collapse. We show that the laser threshold is determined more by the gradients in temperature and pressure than by the global pressure and temperature. We propose that the flow of material into the focus of the laser is observed after the yield stress of the monolayer is overcome. The higher the yield stress, the higher the temperature gradient that is necessary for the monolayer to yield. The local pathway opens only when the derivative of surface pressure with temperature is negative such that stress gradients point toward the laser focus and a sink of material is generated. In such a case we are able to give estimates of the dilatational yield pressure of the solid monolayer.

DY 5.6 Mon 16:15 MA 004

Molecular dynamics and morphology in confined 4-heptan-4-isothiocyanatobiphenyl liquid crystals — •Malgorzata Jasiurkowska[1], Wilhelm Kossack[1], Roxana Enea[1], Ciprian Iacob[1], Wycliffe Kipnusu[1], Periklis Papadopoulos[2], Joshua Sangoro[1], Maria Massalska-Arodz[3], and Friedrich Kremer[1] — [1]Institute of Experimental Physics I, University of Leipzig, Linnestr. 5, 04103 Leipzig, Germany — [2]Max Planck Institute for Polymer Research, Ackermannweg 10, 55128 Mainz, Germany — [3]The Henryk Niewodniczanski Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, 31-342 Kraków, Poland

Molecular dynamics and orientational order of 4-heptan-4-isothiocyanatobiphenyl (7BT) confined in non-intersecting pores of mean diameters from 4 nm to 10.5 nm are studied by a combination of Broadband Dielectric and Fourier-Transform Infrared Spectroscopy.

In contrast to well-known bulk dielectric properties of nBTs, confinement leads to modification of the molecular dynamics. Infrared Transition Moment Orientational Analysis reveals different molecular arrangement in pores of diameters 10.5 nm compared to the molecules enclosed in 4 nm and 6 nm diameter pores

DY 5.7 Mon 16:30 MA 004

Bicontinuous and mixed gels in binary mixtures of patchy colloidal particles — •Daniel de las Heras[1,2], Jose María Tavares[2], and Margarida Telo da Gama[2] — [1]Theoretische Physik II, Physikalisches Institut, Universität Bayreuth, Universitättsstraße 30, D-95447 Bayreuth, Germany — [2]Centro de Física Teórica e Computacional da Universidade de Lisboa, Avenida Professor Gama Pinto 2, P-1649-003, Lisbon, Portugal

We investigate the thermodynamics and percolation regimes of model binary mixtures of patchy colloidal particles [1]. The particles of each species have three interaction sites of two types, one of which promotes bonding of particles of the same species while the other promotes bonding of different species. We find up to four percolated structures at low temperatures and densities: two gels where only one species percolates, a mixed gel where particles of both species percolate but neither species percolates separately, and a bicontinuous gel where particles of both species percolate separately forming two interconnected networks. The competition between the entropy and the energy of bonding drives the stability of the different percolating structures.

Appropriate mixtures exhibit one or more connectivity transitions between the mixed and bicontinuous gels, as the temperature and/or the composition changes.

[1] D. de las Heras, J.M. Tavares, and M.M. Telo da Gama. Accepted for publication in Soft Matter, 2011. (http://arxiv.org/abs/1111.3741)

DY 5.8 Mon 16:45 MA 004

Dynamic phase behaviour of soft colloids — •Sudipta Gupta, Stellbrink Joerg, and Richter Dieter — JCNS1/ICS1, Forschungszentrum Juelich, 52425 Germany

Soft colloids, e.g. polymer-coated silica particles, block copolymer micelles, star polymers etc., are hybrids between (linear) polymer chains and (hard sphere) colloids. Due to this hybrid nature, soft colloids macroscopically show interesting (phase) behaviour resulting from its unique microscopic structure. We introduce kinetically frozen diblock copolymer micelles as an "easy-to-establish" and "tuneable" model system for soft colloids. The micellar architecture was tuned from the star-like to the crew-cut regime by varying the block-ratio. The micellar structure was successfully determined using SANS. At the same time, we are studying the flow properties both at semi-dilute and at concentrated regime for this different block ratio, using rheology. By constructing a dynamic phase diagram we can conclude that the macroscopic flow properties do strongly depend on the microscopic structure determined by SANS. Thereby we investigate the basic principles of the so-called structure-property-relationship (SPR) that finally enables tailoring material properties for technical applications. The change in block ratio significantly affects the phase behaviour of this particular class of soft colloids. A more detailed investigation of this phase behaviour is still under progress.

Topical Talk DY 5.9 Mon 17:00 MA 004

Phason dynamics in light-induced colloidal quasicrystals — •Michael Schmiedeberg[1], Justus Kromer[2], and Holger Stark[2] — [1]Institut für Theoretische Physik 2: Weiche Materie, Heinrich-Heine-Universität Düsseldorf, Germany — [2]Institut für Theoretische Physik, Technische Universität Berlin, Germany

Quasicrystals are non-periodic solids which nevertheless possess long-range positional and orientational order. We study a 2D charge-stabilized colloidal suspension in an external potential with quasicrystalline symmetry. In experiments the potential is realized by five, seven, or more interfering laser beams. A short overview on the properties of light-induced colloidal quasicrystals is presented.

A distinctive physical property of quasicrystals are phasons, which correspond to correlated rearrangements of atoms throughout the quasicrystal. Phasons, like phonons, are hydrodynamic modes since they do not cost free energy in the long-wave-length limit. We perform Brownian dynamics simulations to unravel single-particle dynamics when a constant phasonic drift is applied to the quasicrystalline potential. Single colloids exhibit characteristic trajectories along different directions that are given by their starting positions. Properties of conventional crystals can be deduced from a single unit cell which does not exist in quasicrystals. Nevertheless, we are able to define a characteristic area for phononic and phasonic displacement. We demonstrate that each particle trajectory can then be predicted by mapping it into this area. Our observations help to get a deeper insight into the properties of phasonic displacements in colloidal as well as in atomic quasicrystals.

DY 6: Delay Dynamics

Time: Monday 15:00–16:30 Location: MA 144

DY 6.1 Mon 15:00 MA 144

Cluster synchronization in neural networks with delayed coupling — •Johannes Pardowitz[1], Judith Lehnert[1], Thomas Dahms[1], Philipp Hövel[1,2], and Eckehard Schöll[1] — [1]Technische Universität Berlin, Germany — [2]Bernstein Center for Computational Neuroscience Berlin, Germany

We study zero-lag and cluster synchronization on delay-coupled neural networks, considering simple network motifs and small-world networks of FitzHugh-Nagumo models. We systematically investigate the influence of the network topology and the initial conditions on the dynamical synchronization patterns. In addition, the desynchronization transition induced by additional inhibitory links [1] is discussed.

[1] J. Lehnert, T. Dahms, P. Hövel, and E. Schöll: *Loss of synchronization in complex neural networks with delay*, Europhys. Lett. (2011), in print (arXiv:1107.4195).

DY 6.2 Mon 15:15 MA 144

Dynamical properties of delay-coupled stochastic networks: On spectra, correlations and network topology — •Otti D'Huys[1,2], Raul Vicente[3], Jan Danckaert[2], and Ingo Fischer[4] — [1]Institut für Theoretische Physik, Universität Würzburg, Germany — [2]Applied Physics Research Group (APHY), Vrije Universiteit Brussel, Belgium — [3]Max-Planck-Institute for Brain Research, Frankfurt am Main, Germany — [4]Instituto de Fisica Interdisciplinar y Sistemas Complejos, IFISC (UIB-CSIC), Palma de Mallorca, Spain

The dynamical properties of delay-coupled systems are of high current interest. So far the analysis has concentrated strongly on synchronisation properties. Here, we study how the network structure affects the dynamical properties of the nodes, if they do not synchronise completely. Therefore we study networks of stochastic linear units with delayed coupling, which cannot adapt their output to each other to show identical synchronisation. For these systems we can calculate analytically the correlation functions of the dynamics of different network nodes, and the corresponding spectra.

We find that both the spectrum and the autocorrelation function of a network element can be expressed as the average of the spectra of different single nodes with delayed feedback. We compare the correlation and spectral properties of stochastic linear maps to those of deterministic chaotic dynamical system. Although linear maps cannot show any form of synchrony, simply due to the network structure, they show correlation patterns and spectra that are strikingly similar to those observed in some deterministic chaotic delay-coupled networks.

DY 6.3 Mon 15:30 MA 144

Synchronization in networks of noisy oscillators with delayed coupling — •Andrea Vüllings[1,2], Valentin Flunkert[1], and Eckehard Schöll[1] — [1]Technische Universität Berlin, Germany — [2]Humboldt Universität zu Berlin, Germany

We investigate networks composed of delay-coupled noisy dynamical components. We concentrate on directed and undirected ring networks (regular networks). The local dynamics of each network agent is given by a stable focus, and each node is subject to Gaussian white noise. We discuss the influence of the coupling delay time on the stochastic network dynamics. By decomposing the general solution for the network dynamics into network modes, we analyze the mean square oscillation amplitude of the nodes for variable delay times. We derive an analytic expression for the mean square amplitude and find that by choosing a suitable delay time the noise induced collective oscillations can be enhanced or suppressed. Numerically, we also discuss the case of a Hopf normal form as the local dynamics of the individual network components and compare these simulations to the analytical results obtained for the linear case.

DY 6.4 Mon 15:45 MA 144

Dynamics of semiconductor lasers with delayed polarization-rotated feedback and its application for fast random bit generation — •Neus Oliver[1], Miguel C. Soriano[1], David W. Sukow[2], and Ingo Fischer[1] — [1]Instituto de Física Interdisciplinar y Sistemas Complejos (IFISC) CSIC-UIB, Campus Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain — [2]Department of Physics and Engineering, Washington and Lee University, Lexington, Virginia 24450 USA.

Chaotic dynamics of semiconductor lasers has been proven attractive for fast random bit generation. Simple and robust systems, along with a systematic approach determining the required dynamical properties and most suitable conditions are key to achieve this goal. We show that the dynamics of a single mode laser with polarization-rotated feedback is very attractive for random bit generation. The delayed feedback induces dynamical instabilities characterized by a broad RF spectrum and corresponding chaotic dynamics of the output signal. We identify the optimal operating conditions and derive the sampling conditions to achieve randomness. Finally, we introduce a simple postprocessing procedure and study its role to enhance randomness. Applying the identified criteria, we achieve fast random bit generation rates up to multi-Gbit/s with a simple and robust system and minimal postprocessing requirements.

DY 6.5 Mon 16:00 MA 144

Strong and Weak Chaos in Nonlinear Networks with Time-Delayed Couplings — •Sven Heiligenthal[1], Thomas Dahms[2], Serhiy Yanchuk[3], Thomas Jüngling[1], Valentin Flunkert[2], Ido Kanter[4], Eckehard Schöll[2], and Wolfgang Kinzel[1] — [1]University of Würzburg, Würzburg, Germany — [2]Technical University of Berlin, Berlin, Germany — [3]Humboldt University of Berlin, Berlin, Germany — [4]Bar-Ilan University, Ramat-Gan, Israel

We investigate networks of nonlinear units with time-delayed couplings in the limit of large delay times. We find two kinds of chaos which we call strong and weak. For strong chaos the largest Lyapunov exponent (LE) is of the order of the inverse time scales of the individual units. For weak chaos the largest LE is of the order of the inverse delay time. As a consequence, networks with strong chaos cannot synchronize, whereas for weak chaos, networks can synchronize if the product of the largest LE and the delay time is sufficiently small compared to the eigenvalue gap of the coupling matrix. We can prove that the occurrence of strong and weak chaos is determined by the sign of the instantaneous LE. For semiconductor lasers, numerical simulations of the Lang-Kobayashi equations predict that by monotonically increasing the strength of the time-delayed coupling or feedback, the chaos changes from weak to strong and back to weak chaos. We suggest an experimental setup to measure the difference between strong and weak chaos, which we have realized in an experiment with two coupled electronic circuits.

See also: S. Heiligenthal *et al.*, Phys. Rev. Lett. **107**, 234102 (2011).

DY 6.6 Mon 16:15 MA 144

Experimental control of chaos by variable and distributed delay feedback — •Thomas Jüngling[1], Aleksandar Gjurchinovski[2], and Viktor Urumov[2] — [1]Institute for Theoretical Physics, University of Würzburg, Germany — [2]Faculty of Natural Sciences and Mathematics, Saints Cyril and Methodius University of Skopje, Macedonia

Unstable steady states can be stabilized by time-delayed feedback with variable or distributed delay. Compared to the classical control method with a single constant delay, it has been theoretically shown that such kind of feedback can improve the stability properties significantly. Here we investigate this phenomenon experimentally for a chaotic electronic circuit. Time-delayed signals are obtained by use of digital delay lines, which are driven by an external clock. A modulation of the clock frequency results in a delay time modulation. The use of many delay lines as well as the application of filters results in a delay distribution. The steady state of the oscillator could be stabilized with these methods for comparably large sets of parameters, confirming the theoretical prediction and the robustness of the presented technique. A restricted version of our control scheme was successfully applied to the control of unstable periodic orbits, also resulting in improved stabilization. Finally, an intuitive explanation of the phenomenon is given in terms of classical diffraction and interference.

DY 7: Reaction-Diffusion-Systems

Time: Monday 16:45–18:30 Location: MA 144

DY 7.1 Mon 16:45 MA 144

Influence of boundaries on the intrinsic dynamics of excitation waves — •Jan Frederik Totz[1], Oliver Steinbock[2], and Harald Engel[1] — [1]Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, EW 7-1, D-10623 — [2]Department of Chemistry and Biochemistry, Florida State University, Tallahassee, FL-32306-4390

Three-dimensional excitation waves are thought to play a fundamental role in serious cardiac diseases such as tachycardia and fibrillation. We employ the well-studied Belousov-Zhabotinsky-Reaction as a chemical model system to investigate the altered dynamics of scrollrings close to boundaries, using an experimental setup as described in [1]. We observed four different scenarios of the scrollring evolution dependent upon the distance to the nearest zero-flux boundary: Annihilation at the boundary, weakly & strongly boundary-affected scrollring contraction rates and even vanishingly small contraction. The experimental findings are in good agreement with previous numerical results [2].

[1] Z. A. Jiménez, B. Marts, O. Steinbock, Phys. Rev. Lett. 102, 244101 (2009)

[2] M. Bray, J.P. Wikswo, Phys. Rev. Lett. 90, 23 (2003)

DY 7.2 Mon 17:00 MA 144

Spiral wave selection in excitable media with a phase wave at the wave back — •Vladimir Zykov, Noriko Oikawa, and Eberhard Bodenschatz — Max Planck Institute for Dynamics and Self-Organization, D-37077 Goettingen, Germany

Universal relationships between the medium excitability and the angular velocity and the core radius of rigidly rotating spiral waves in excitable media are derived for situations where the wave front is a trigger wave and the wave back is a phase wave [1]. Such trigger-phase (TP)-waves are equally important for applications as commonly studied trigger-trigger (TT)-waves. Two universal limits restricting the region of existence of spiral TP-waves in the parameter space are demonstrated. The predictions of the free-boundary approach are in good quantitative agreement with results from numerical reaction-diffusion simulations performed on the Kessler-Levine model.

The proposed free-boundary approach opens perspectives to analyze TP-spiral waves in different kind of models including such important applications as chemical or cardiac excitable media.

1. V.S. Zykov, N. Oikawa, and E. Bodenschatz, Phys. Rev. Lett., accepted.

DY 7.3 Mon 17:15 MA 144

Speed-up of a clock reaction with microfluidic methods — •Robert Niedl, Igal Berenstein, and Carsten Beta — Biological Physics, Universität Potsdam, Germany

The focus of our research is a combination of nonlinear kinetics and microfluidics to amplify chemical input signals. We study the dynamics of the autocatalytic iodate-arsenite reaction in PDMS-based microfluidic devices under continuous flow conditions. If a critical amount of initializer is present, a reaction is triggered by a nonlinear autocatalytic process. In our experimental setup two different scenarios are implemented to initiate the reaction. On the one hand, we use diffusive micromixing to systematically investigate the kinetics of the clock depending on the various input concentrations, flow velocities, and fluid viscosities. On the other hand, we introduce a Pt electrode into the microchannel that acts as a local chemical source in the flow. This

setup allows us to explore the interplay of mixing kinetics and nonlinear reaction that may lead to accelerated reaction rates in specific microfluidic configurations.

DY 7.4 Mon 17:30 MA 144

Parameter estimation for reaction-diffusion systems — •Andreas Ruttor and Manfred Opper — Technische Universität Berlin

Spatial fluctuations of the particle density in reaction-diffusion systems are often modelled by dividing the system into small compartments. In this case, additional transfer reactions describe the diffusion, so that methods for homogeneous reactions systems can be used in order to estimate parameters. However, finding a suitable discretization is not easy: if the compartments are too big, important spatial structure contained in the observations is lost. But using smaller compartments increases the complexity of the calculations. In order to solve this problem, we propose a more fundamental approach. Instead of using compartments directly, we transform the model into Fourier space and calculate the continuum limit analytically. As before, the dynamics of the system is described by its Fokker-Planck equation. We then apply system size and weak noise expansions, which lead to a Gaussian approximation suitable for efficient parameter estimation. It turns out that only low-frequency moments are relevant here, while higher frequencies mostly contain noise. This also applies to the observations, as it is impossible to measure all details of the spatial fluctuations. Consequently, only a small number of moments in Fourier space are needed for calculating the total likelihood, usually less than in the case of compartment models.

DY 7.5 Mon 17:45 MA 144

Non-equilibrium reaction-diffusion structures in Poiseuille flows: A Lattice Boltzmann study — •Segun Gideon Ayodele — Max-Planck Institute für Eisenforchung, Düsseldorf, Germany.

Solutions of the reaction-diffusion equations are know to exhibit a wide variety of spatially and/or temporally varying structures [S.G. Ayodele et. al. Phys.Rev.E. 80,016304 (2009), S.G. Ayodele et. al. Phys.Rev.E. 83,016702 (2011)]. In this work we study spatially varying structures arising from the interaction of advective transport with an autocatalytic reaction-diffusion process under an imposed Poiseuille flow. Structures resulting from the interaction of the 2D Poiseuille flow with the reaction-diffusion process takes place via two mechanisms. A differential advection induced instability and a flow independent Turing instability. The differential advection mechanism leads to traveling stripes with a velocity dependent wave vector parallel to the flow direction. The second mechanism similar to the Turing instability produces longitudinal stripes aligning along the streamlines with a velocity independent wave vector perpendicular to the flow direction. The symmetry of the patterns in the case of Turing instability are found to be similar to the symmetry of the underlying advective fields. We observe a parameter range where a competition between the two mechanism produces mixed modes comprising of transverse and longitudinal stripes. Using predictions from linear and weakly-nonlinear theory we propose an explanation of this behaviour in terms of the effective diffusivities due to Taylor dispersion.

DY 7.6 Mon 18:00 MA 144

Proton-transfer barriers in low-temperature hexagonal ice from computer simulations — •Christof Drechsel-Grau and Dominik Marx — Lehrstuhl für Theoretische Chemie, Ruhr-Universität Bochum, 44780 Bochum, Germany

Hexagonal ice exhibits remarkable properties. For instance, the proton positions remain disordered down to low temperatures ($\approx 10\,\mathrm{K}$), thereby giving rise to the residual entropy of ice, which stems from many configurations of the hydrogen-bond network even in the absence of defects. Collective proton-transfer or proton-tunnelling events may connect different (defect-free) proton configurations. Unravelling the proton dynamics would not only shed light on properties of ice, but might also contribute to our understanding of liquid water. In this contribution we investigate whether the barriers between different configurations are sufficiently low for proton dynamics to occur even at low temperature. In particular, we describe the electronic structure via density-functional theory and take into account nuclear quantum effects by means of path-integral simulations. First results indicate that the classical barrier is significantly higher than its quantum counterpart, thereby underlining the importance of nuclear quantum effects.

DY 7.7 Mon 18:15 MA 144

Reaction-Diffusion-Systems with various Distributions of Binding Energies — •Andrea Wolff[1], Ingo Lohmar[2], and Joachim Krug[1] — [1]Institut für theoretische Physik, Universität zu Köln, Deutschland — [2]Racah Institute of physics, The Hebrew University, Jerusalem, Israel

We study pair reactions on a periodic square lattice with continuous deposition, diffusion, and spontaneous desorption of particles. The characteristic quantity of the system's steady state is the efficiency, which is the fraction of incoming particles, that react before desorption.

Since spatial inhomogeneity is of theoretical and applied interest, we want to study the influence of disorder in the process rates systematically. We start with binary disorder, where each site has one of two possible different binding energies. The behavior of this system has been well-understood qualitatively and quantitatively [1]. In contrast, the case of continuously distributed binding energies cannot be treated exactly anymore. We use the knowledge of the binary system to derive a mapping from the system with a continuous distribution to an effective binary model, where all the different binding energies are pooled into two effective ones [2]. Comparison of this effective model with Monte Carlo simulations shows remarkable agreement.

[1] A. Wolff, I. Lohmar, J. Krug, Y. Frank, O. Biham, Phys. Rev. E 81, 061109 (2010)

[2] A. Wolff, I. Lohmar, J. Krug, O. Biham, J. Stat. Mech. 10, P10029 (2011)

DY 8: Glasses I (with CPP, talks by CPP)

Time: Monday 15:00–17:30 Location: C 243

Invited Talk DY 8.1 Mon 15:00 C 243

Glass transition by molecular network topology freezing and discovery of vitrimers — •Ludwik Leibler, Damien Montarnal, Mathieu Capelot, and François Tournilhac — Matière Molle et Chimie, ESPCI, 10, rue Vauquelin, 75005 Paris, France

We will discuss a concept and practical realizations of a glass transition by reversible topology freezing of a molecular network. Permanently cross-linked materials, like thermosets or rubbers, have outstanding mechanical properties and solvent resistance, but they cannot be processed and reshaped once synthesized. Non-cross-linked polymers and those with reversible cross-links are processable, but they are soluble. We design epoxy networks able to rearrange their topology by exchange reactions without depolymerization and show that they are insoluble and processable. Unlike organic compounds and polymers whose viscosity varies abruptly near glass transition, these networks, vitrimers, show Arrhenius-like gradual viscosity variations just like vitreous silica. Like silica, the vitrimers can be wrought and welded to make complex objects by local heating without the use of molds. The concept of a glass, made by reversible topology freezing in epoxy networks can be readily scaled up for applications and generalized to other chemistries.

Topical Talk DY 8.2 Mon 15:30 C 243

Elastic Properties of 2D amorphous solids — •Peter Keim — Universität Konstanz

Using positional data from video-microscopy of a two-dimensional colloidal system and from simulations of hard discs we determine the wave-vector-dependent normal mode spring constants in the supercooled fluid and glassy state, respectively. The emergence of rigidity and the existence of a displacement field in amorphous solids is clarified. Continuum elastic theory is used in the limit of long wavelengths to analyze the bulk and shear modulus of this amorphous system as a function of temperature. The onset of a finite static shear modulus upon cooling marks the fluid/solid transition. This provides an opportunity to determine the glass transition temperature T_G in an intuitive and precise way.

DY 8.3 Mon 16:00 C 243

Heterogeneous shear in hard sphere glasses — •Fathollah Varnik[1,2], Suvendu Mandal[2], and Dierk Raabe[2] — [1]ICAMS, Ruhr University Bochum, Germany — [2]Max-Planck-Institut fuer Eisenforschung, Duesseldorf, Germany

There is growing evidence that the flow of driven amorphous solids is not homogeneous, even if the macroscopic stress is constant across the system [1,2]. Via event driven molecular dynamics simulations of a hard-sphere glass, we provide first direct evidence for a correlation between the fluctuations of the local volume-fraction and the fluctuations of the local shear rate [3]. Higher shear rates do preferentially occur at regions of lower density and vice versa. The temporal behavior of fluctuations is governed by a characteristic time scale, which, when measured in units of strain, is independent of shear rate in the investigated range. Interestingly, the correlation volume is also roughly constant for the same range of shear rates. A possible connection between these two observations is discussed.

[1] F. Varnik, L. Bocquet, J.-L. Barrat, L. Berthier, Phys. Rev. Lett. 90, 095702 (2003).

[2] R. Besseling, L. Isa, P. Ballesta, G. Petekidis, M.E. Cates, W.C.K. Poon, Phys. Rev. Lett. 105, 268301 (2010).

[3] S. Mandal, M. Gross, D. Raabe, F. Varnik, submitted to Phys. Rev. Lett.

DY 8.4 Mon 16:15 C 243

Effect of cross-link density on re-entrant melting of microgel colloids — •Malte Wiemann[1], Norbert Willenbacher[2], and Eckhard Bartsch[1,3] — [1]University of Freiburg, Department of Physical Chemistry, Freiburg, Germany — [2]Karlsruhe Institute of Technology, Department of Mechanical Process Engineering and Mechanics, Karlsruhe, Germany — [3]University of Freiburg, Department of Macromolecular Chemistry, Freiburg, Germany

Fluid states of colloidal dispersions at volume fractions above the glass transition can be accessed by introducing short-ranged depletion attraction [1]. For a binary mixture of PS-microgel particles (crosslinking density 1:50) in a good organic solvent DLS-measurements revealed a fluidization up to a volume fraction ϕ=0.69 when linear nonadsorbing polymer is added. The high packing fraction up to which fluid states could be observed raised the question whether the magnitude of this effect is a specialty of the microgel system. We prepared microgels with a much higher crosslinking density (1:10) which should be a good approximation of hard sphere colloids. Fluid states could again be obtained above ϕg, however, up to a significantly smaller packing fraction. The amount of free polymer needed to fluidize the dispersion was much lower as compared to the previous mixture [2]. The existence of fluid states up to high volume fractions for the 1:50 crosslinked particles is - at least partially - a microgel effect which is at present not fully understood and possible origins will be discussed. [1] K. Dawson etal., Phys. Rev. E 63, 011401 (2000) [2] M. Wiemann, N. Willenbacher, E. Bartsch, Colloid Surface A, 10.1016/j.colsurfa.2011.11.029

DY 8.5 Mon 16:30 C 243

Epoxy resins in confined geometry — •Anna Silex, Jörg Baller, and Roland Sanctuary — Laboratory of Physics of Condensed Matter and Advanced Materials, University of Luxembourg, 162A, Avenue de la Faiencerie, L-1511 Luxembourg

In order to exemplarily study the influence of confinement on the behavior of a widely used epoxy resin (Diglycidil Ether of Bisphenol A, DGEBA), we have filled mesoporous glasses with different pore radii with the low molecular weight liquid. Several confinement effects are known to take influence on the glass transition of small molecule liquids. Firstly, interactions between the glass former and the large internal surface of the porous glass lead to a slowing down of the molecular dynamics. Secondly, the confinement of the liquid molecules by the pores and the layer is generally known to accelerate the molecular dynamics. Finally, negative pressure building up in the pores due to the mismatching thermal expansion coefficients of the liquid and the porous glass is discussed to lead to a lower glass transition temperature compared to the pure materials. We present experimental results obtained for DGEBA-porous glass systems with stochastically modulated calorimetry and thermo-mechanical analysis. Thereby the focus is on the influence of the pore size on the glass transition behavior of the guest material but also on the macroscopic characteristics of the complete system as a result of the confinement. Differences between the thermal expansion of the empty and DGEBA filled samples are highlighted.

DY 8.6 Mon 16:45 C 243

Glassy dynamics of isolated polymer coils — •Martin Tress, Emmanuel Mapesa, and Friedrich Kremer — Universität Leipzig, Leipzig

For the first time, the glassy dynamics of randomly distributed, isolated poly(2-vinylpyridine) (P2VP) polymer coils is studied by means of Broadband Dielectric Spectroscopy (BDS). This is achieved by recently developed nano-structured electrode arrangements where isolated polymer coils are deposited onto ultra-flat, highly conductive silicon electrodes. Atomic Force Microscopy scans of the identical sample before and after the BDS measurement prove that the volume of the coils matches, within a factor of 10 (reflecting the broad molecular weight distribution), with the expected volume of a single chain (considering bulk density and the respective molecular weight). The observed dynamics compares well with that of bulk but is slowed down by a factor of about 10. This is attributed to attractive interactions of the P2VP segments with the supporting silica surface.

DY 8.7 Mon 17:00 C 243

Reduced Glass Transition Temperatures of Thin Polymer Films - Confinement Effect or Artifact? — •Oliver Bäumchen[1], Joshua D. McGraw[1], James A. Forrest[2], and Kari Dalnoki-Veress[1] — [1]Department of Physics & Astronomy and the Brockhouse Institute for Materials Research, McMaster University, Hamilton, ON, Canada, L8S 4M1 — [2]Department of Physics and Astronomy and Guelph-Waterloo Physics Institute, University of Waterloo, Waterloo, ON, Canada, N2L 3G1

For two decades there have been reports of measurements of reduced glass transition temperatures (T_g) in polymer, and in particular polystyrene, films. These results have motivated theoretical models and a variety of sophisticated experiments probing interfacial polymer properties. While the much larger reductions in T_g for free standing films have suggested the importance of the free surface, a significant concern has been raised about a possible correlation between anomalous dynamics and incomplete equilibration of the sample. Here, we present new ellipsometry measurements which unambiguously address this concern. The glass transition in free standing and supported films can be changed by many 10's of degrees by manipulating the interfacial properties. Taken together with previous work the results clearly reveal the importance of free interfaces as we transition from two, to one, to zero free interfaces.

DY 8.8 Mon 17:15 C 243

Molecular Mobility and Glass Transition of Thin Poly(Bisphenol A Carbonate) Films — •Huajie Yin and Andreas Schönhals — BAM Federal Institute for Materials Research and Testing, Unter den Eichen 87, 12205 Berlin, Germany

Glass transition behavior of thin poly(bisphenol A carbonate) (PBAC) films (down to 10 nm) was investigated using capacitive dilatometry (CD), broadband dielectric spectroscopy (BDS) and differential ac-chip calorimeter (DACC) accompanied by contact angle measurements. In the BDS measurements of the thin PBAC films capped between two Al layers, no thickness dependence of the segmental dynamics was detected down to a critical thickness of 20 nm. For thickness below 20 nm, an increase of the relaxation time at a fixed temperature was observed. The thickness dependence of the thermal glass transition temperature determined by CD is in agreement with BDS results. Dynamic glass transition temperature of the ultra-thin PBAC films (10-55 nm) supported on SiO2 layer, with one free surface, was studied by means of differential ac-chip calorimeter as well. No thickness dependence of the dynamic glass transition temperature was observed within an uncertainty of +/-3 K for each frequency. These experimental results are discussed in terms of the different interactions of polycarbonate segments with the different substrates and/or different preparation conditions.

DY 9: Statistical Physics of Biological Systems II (with BP, talks from BP)

Time: Monday 15:00–17:30 Location: H 1058

DY 9.1 Mon 15:00 H 1058

The probability of parallel evolution — •Joachim Krug[1], Ivan G. Szendro[1], Martijn F. Schenk[2,3], and J. Arjan G.M. de Visser[3] — [1]Institut für Theoretische Physik, Universität zu Köln, Germany — [2]Institut für Genetik, Universität zu Köln, Germany — [3]Laboratory for Genetics, Wageningen University, Netherlands

The question whether evolutionary processes are repeatable is of central importance in evolutionary biology and continues to be vigorously debated. In a simple version of this problem introduced by Orr, one considers a situation where n beneficial mutations are available to an organism and asks for the probability P that the same mutation is fixed in two replicate populations. When the fitness values are drawn from a distribution that belongs to the Gumbel domain of attraction, Orr showed that $P = 2/(n+1)$, about twice the neutral expectation $1/n$ that would apply if all mutations were equally likely to fix. Motivated by recent experiments that observed a heavy-tailed distribution of fitness effects in an antibiotic resistance gene, we extend Orr's analysis to distributions of selection coefficients s of Pareto form, $f(s) \sim s^{-(\alpha+1)}$. Using an approach from the statistical physics of disordered systems, we show that the probability of parallel evolution is dramatically enhanced when $\alpha < 2$, with $P \sim n^{-(2-\alpha)}$ for $1 < \alpha < 2$ and $P = const.$ for $\alpha < 1$. We also briefly address the influence of population size on the probability of parallel evolution.

DY 9.2 Mon 15:15 H 1058

Evolution of cooperation in microbial biofilms - A stochastic model for the growth and survival of bacterial mats — •Johannes Knebel, Anna Melbinger, Jonas Cremer, and Erwin Frey — LMU Muenchen, Deutschland

Cooperating microbes are widespread in nature despite running the risk of being exploited by free-riders. This so-called dilemma of cooperation is especially important for microbial biofilms where diverse different strains interact in a complex community. The structure and composition of such a biofilm change over time and thereby influence the evolution of cooperation within the system. In turn, the level of cooperation affects the growth dynamics of the biofilm.

Here, we investigate this coupling for an experimentally well-defined situation in which mutants of the Pseudomonas fluorescens strain form a mat at the liquid-air interface by the production of an extra-cellular matrix [1]. We model the occurrence of cooperation in this bacterial population by taking into account the formation of the mat. The presence of cooperators enhances the growth of the mat, but at the same time cheaters can infiltrate the population and put the viability of the mat at risk. We find that the survival time of the mat crucially depends on its initial dynamics which is subject to demographic fluctuations [2]. More generally, our work provides conceptual insights into the requirements and mechanisms for the evolution of cooperation.

[1] P. Rainey et al., Nature 425, 72 (2003).
[2] A. Melbinger et al., PRL 105, 178101 (2010).

DY 9.3 Mon 15:30 H 1058

Meso-scale symmetries explain dynamical equivalence of food webs — •Helge Aufderheide[1,2], Lars Rudolf[2], and Thilo Gross[2] — [1]MPI für Physik komplexer Systeme, Dresden — [2]University of Bristol, Bristol

In complex networks much of the dynamics emerges from the complex interactions between its constituents. However, connecting the interaction topology with the final dynamics remains a hard and largely unsolved problem. Inspired by a recent result on the dynamical equivalence of food webs differing only by local symmetries in their trophic graph, we investigate the effects of such symmetries on the dynamics of food webs. Using generalized modeling to establish the food web Jacobian matrix near the steady states we can study entire classes of food web models instead of fixing specific functional dependencies between the interacting species. Thereby we find that food webs differing by local symmetries indeed carry identical dynamics up to effects localized inside the symmetric part. On one hand this result for equivalent dynamics provides a link between the topology and the dynamical properties of a food web. On the other hand the formalism should be applicable to identify classes of equivalent dynamics hidden to empirical observation in more complicated systems.

DY 9.4 Mon 15:45 H 1058

Geometrical trajectories of a Listeria-type actin-driven particle in 2D — •Fu-Lai Wen[1], Kwan-tai Leung[1,3], and Hsuan-Yi Chen[1,2,3] — [1]National Central University, Jhongli, Taiwan 32001, Republic of China — [2]Physics Division, National Center for Theoretical Sciences, Hsinchu, Taiwan 30113, Republic of China — [3]Institute of Physics, Academia Sinica, Taipei, Taiwan 11529, Republic of China

Self-propulsions have been a focus of the non-equilibrium statistical physics where an input energy is converted into the kinetic energy of motion. It is interesting that a deformable self-propelled domain is shown to generate a series of geometrical trajectories like circles, wiggles, etc. A similar result is also found in the motion of a bacterium Listeria which, although not deformable, moves in a geometrical trajectory by the polymerization of protein actin on its surface. Similar actin-driven motility was also shown in vitro studies on functionalized beads or disks. Here, a phenomenological model is constructed for the generation of geometrical trajectories of a Listeria-type actin-driven spherical particle in two dimensions. In our model, the evolutions of actin filament density and force on surface are coupled to the translation and rotation of the particle which in turn are determined by those densities. It is shown that this feedback can destabilize the straight trajectories and lead to the geometrical trajectories observed in experiments. It further shows that a straight trajectory transits to a circular one through a pitchfork bifurcation or to a wiggled one through a Hopf bifurcation on the distributions of those densities. This transition mechanism is generic and robust as indicated in our studies.

DY 9.5 Mon 16:00 H 1058

Mean Exit Time of a Brownian Particle from a Spherical Domain with Multiple Exit Sites on the Boundary — •Ronny Straube[1], Michael J. Ward[2], and Alexei F. Cheviakov[3] — [1]Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg — [2]University of British Columbia, Vancouver, Canada — [3]University of Saskatchewan, Saskatoon, Canada

In biological signal transduction a target molecule often has to find a small exit site on an otherwise impermeable boundary. Important examples of such **narrow escape** processes include diffusion through ion channels and trafficking through pores of the nuclear membrane. We have recently extended the calculation of the mean exit time (MET) from the case of a Brownian particle exiting from a spherical domain with a single exit site [1] to the case of multiple exit sites [2]. Using the method of matched asymptotic expansions we provide a three-term approximation of the MET which explicitly depends on the spatial configuration of the exit sites. We show that for a fixed surface fraction of exit sites the MET reaches a value close to its minimum already for 30-40 exit sites which suggests, for example, that cell nuclei have many more pores than would be needed if nuclear export was a purely diffusion-limited process.

[1] Singer A, Schuss Z, Holcman D, Eisenberg RS. Narrow escape, part I. J. Stat. Phys. 122, 437-463 (2006).
[2] Cheviakov AF, Ward MJ, Straube R. An asymptotic analysis of the mean first passage time for narrow escape problems: part II: The sphere. SIAM Multiscale Model. Simul. 8, 836–870 (2010).

DY 9.6 Mon 16:15 H 1058

Fractional Brownian Motion in Crowded Fluids — Dominique Ernst[1], Marcel Hellmann[2], Jürgen Köhler[1], and •Matthias Weiss[2] — [1]Experimental Physics IV, University of Bayreuth, D-95440 Bayreuth — [2]Experimental Physics I, University of Bayreuth, D-95440 Bayreuth

Diffusion in crowded fluids, e.g. in the cytoplasm of living cells, has frequently been reported to show an anomalous characteristics ('subdiffusion'). Several random walk models have been proposed to explain these observations, yet so far an experimentally supported decision in favor of one of these models has been lacking. Here, we show that experimentally obtained trajectories in a prototypical crowded fluid show an ergodic behavior and an asphericity that is most consistent with the predictions of fractional Brownian motion, i.e. an anti-correlated, anti-persistent generalization of normal Brownian motion that is related to the fluid's viscoelasticity.

DY 9.7 Mon 16:30 H 1058

Time domain representation of active nonlinear cochlear waves — •Florian Fruth[1,2], Frank Jülicher[1], and Benjamin Lindner[2] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden — [2]Bernstein Center for Computational Neuroscience, Philippstr. 13, Haus 2, 10115 Berlin

The inner ear, the so called cochlea, can be modeled generically in terms of coupled critical oscillators, which has been done previously in the frequency (Fourier) domain. This one-dimensional model describes a nonlinear cochlear wave that is pumped by active oscillators. We extend and generalize this model by constructing a similar version in time domain, in order to include dynamical noise (originating, e.g. in the stochastic activity of outer hair cells) and static disorder (resulting from inhomogeneities of system parameters along the cochlea). We discuss the spontaneous oscillations in the model and also investigate its response to external stimuli such as clicks or pure tones.

DY 9.8 Mon 16:45 H 1058

The effects of temperature changes on the timing of cell division — •Federico Vazquez[1,2], Abigail Klopper[3], Maria Begasse[2], and Stephan Grill[1,2] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Max Planck Institute for Molecular Cell Biology and Genetics — [3]Nature Publishing Group

Accurate timing of early embryogenesis is crucial for the development of an organism, and is subject to sensitive dependence on fluctuations in temperature. We investigate how timing is affected by temperature using *C.* elegans as a model organism, which benefits from rapid early cell divisions and an inability to maintain a constant body temperature, independent of ambient conditions. Experiments show that cell division rates have an Arrhenius dependence on temperature in an intermediate range, but they continuously deviate from this law outside this range, that is, for high and low temperatures. We propose a simple model for cell division, in which the state of the cell performs a Brownian motion on a complex network with temperature-dependent hopping rates, and associate division rates to mean first-passage times. We obtain analytical expressions for simple topologies that fit the experimental data very well, showing that the fundamental mechanism behind the temperature dependence rates can be captured by a very low dimensional system. By comparing timings between different phases as a function of temperature, we are able to relate the lack of event coordination to the malfunction of the cell cycle at extreme temperatures. We also compare rates of *C.* elegans and *C.* briggsae, two closely related organisms known to differ in their optimal temperature range.

DY 9.9 Mon 17:00 H 1058

Spatial organization of the cell cytoplasm: Amplifying protein concentration gradient by phase separation — •Chiu Fan Lee[1], Clifford P. Brangwynne[2], Jöbin Gharakhani[1], Zdeněk Petrášek[3], Petra Schwille[3], Anthony A. Hyman[4], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Chemical and Biological Engineering, Princeton University, USA — [3]Biotechnologisches Zentrum, Dresden, Germany — [4]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany

Pattern formation in the cell cytoplasm plays an important role in a number of biological processes. During cell division, the cell cytoplasm undergoes dramatic spatial reorganization. In the case of asymmetric cell division, cytoplasmic components are segregated spatially. An intriguing example is the spatial organization of the cytoplasm during asymmetric cell division in the C. elegans embryo, which involves the generation of a concentration gradient of the protein Mex-5 that in turn localizes P granules to the posterior side. P granules are liquid drops consisting of RNA and proteins that are important for germline specification. Combining theory and quantitative experiments, we propose a simple scenario that describes how the Mex-5 concentration gradient controls the spatial profile of P granule formation and the localization of P-granules to the posterior of the cell. Furthermore, we demonstrate that with the help of phase separation based on the Flory-Huggins formalism, the P granule concentration gradient can be drastically amplified in comparison to the Mex-5 concentration gradient.

DY 9.10 Mon 17:15 H 1058

Molecular Force Response Characteristics from Power Spectral Analysis of Optical Tweezer Experiments — •Yann von Hansen[1,2], Alexander Mehlich[1], Benjamin Pelz[1], Michael Hinczewski[1,3], Matthias Rief[1], and Roland R. Netz[1,2] — [1]Physik Department, TU München — [2]Fachbereich Physik, FU Berlin — [3]IPST, University of Maryland, USA

The thermal fluctuations of micron-sized beads in dual trap optical tweezer experiments contain a wealth of dynamic information about the viscoelastic properties of the experimental object of study. Dynamic deconvolution theory relates the beads' power spectral densities (PSDs) and the mechanic force response of individual components in the mechanic network [1]. For the quantitative evaluation of the measured signals, a detailed understanding of instrumental characteristics and an accurate calibration of the setup are required. For a simple model system, a pair of unconnected, but hydrodynamically interacting spheres, we obtain excellent agreement between theoretical and measured self- and cross-PSDs over a wide range of inter-bead distances and frequencies, for motion parallel and perpendicular to the inter-bead axis. A comparison to theoretical predictions based on instantaneous hydrodynamics emphasizes the importance of hydrodynamic retardation effects. The viscoelastic response of the force-transducing element between the beads in more complex experimental constructs can be obtained applying a maximum likelihood method [2].

[1] M. Hinczewski et al., Proc. Natl. Acad. Sci. USA 107, 21493 (2010)
[2] Y. von Hansen et al., manuscript in preparation

DY 10: Nonlinear Dynamics, Synchronisation and Chaos

Time: Tuesday 9:30–13:00 Location: MA 001

DY 10.1 Tue 9:30 MA 001

On nonlinear waves spreading in two-dimensional random lattices — •Tetyana V. Laptyeva, Joshua D. Bodyfelt, and Sergej Flach — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

We analyze the mechanisms and regimes of nonlinear waves spreading in random lattices, which are known to localize linear waves. More precisely, we extend our recent studies on the strong and weak chaos regimes of wave-packet subdiffusive spreading [1] to the case of two-dimensional lattices with tunable nonlinearity. The focus is put on the paradigmatic problem of compact excitation expansion in disordered (Klein-Gordon) lattice with a σ-parameterized nonlinearity $|u|^\sigma u$. Numerically obtained time-dependencies for the subdiffusion exponents support theoretical predictions of [2]. Moreover, going below critical nonlinearity power $\sigma_c = 1$ we observe the long-lasting strong chaos in subdiffusive wave-packet spreading. The possible ways of estimation, or, qualitative characterization of this process remain open for further exploration.

[1] T.V. Laptyeva, et al., Europhys. Lett. 91, 30001 (2010); J.D. Bodyfelt, et al., Phys. Rev. E 84, 016205 (2011); J.D. Bodyfelt, et al., Int. J. Bif. Chaos 21, 2107 (2011). [2] S. Flach, Chem. Phys. 375, 548 (2010).

DY 10.2 Tue 9:45 MA 001

Effects of rotation on the nonlinear friction of a damped dimer sliding on a periodic substrate — •Italo Neide — Faculty of Physics - University Duisburg-Essen, Duisburg, Germany

The aim of this work is to study the effects of rotation of the non linear friction of a damped dimer sliding on a 1D periodic substrate. Numerical simulations are performed with: a damping in the translational and rotational coordinate, throwing the dimer with a finite initial translational velocity (transient state); with the dimer subjected to an external force applied in the center of mass coordinate and with finite temperatures (steady state). The equations of motion in terms of center of mass and rotational coordinate show a roto-translational coupling, whose is activated for distinct regimes while the dimer is sliding, resulting in an energy transfer between the coordinates. The motivation of this work is to understand the rotational effects that emerges from the dynamics of the smallest object that can rotate, in order to achieve simple contributions to the understanding of the friction origin in nanometric scale.

DY 10.3 Tue 10:00 MA 001

Intraband dynamics in a one dimensional (1D) nonlinear Wannier-Stark ladder — •Petruta Anghel-Vasilescu and Sergej Flach — Max-Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany

I will present new results on the dynamics of a wave packet in a 1D nonlinear Wannier-Stark ladder in the absence of interband Landau-Zener tunneling and discuss the observed different regimes of spreading of an initial single-site excitation. In the linear Wannier- Stark problem, the eigenvalue spectrum is equidistant and all normal modes are spatially localized. Nonlinearity induces frequency shifts and mode-to-mode interactions which can destroy the localization. For large values of the nonlinear coefficient we observe single-site trapping as a transient regime, followed by an explosive spreading and subdiffusion. For moderate nonlinearity strength the subdiffusion is found to be the only spreading regime. Finally for small nonlinearities we find linear Stark localization due to the presence of nonlinear Bloch oscillations. The sub-diffusive spreading was found to be very dependent on the strength of the applied electric field.

DY 10.4 Tue 10:15 MA 001

Frequency Analysis of Diffusion Processes in Coupled Standard Maps Using Graphics Cards — •Moritz Schönwetter[1,2], Sebastian Schröter[2], Peter Schlagheck[3], and Javier Madroñero[2] — [1]MPIPKS Dresden — [2]TU München — [3]Université de Liège, Belgium

An accurate description of phenomena arising in higher dimensional classical systems – e.g. dynamical tunneling [1] or stickiness [2] – requires the knowledge of the long term behaviour of a huge number of trajectories. This involves numerically challenging calculations which nowadays can be solved on reasonable time-scales with the use of modern Graphic Processing Units (*GPU*s).

In the present contribution we consider the complex dynamics of two coupled standard maps. Using the methods of (time-) frequency analysis [3] and classical perturbation theory we investigate the associated Arnold web of resonances in appropriate coordinates. Special attention is dedicated to possible diffusion channels which are observed in the long-time evolution of this web.

[1] O. Brodier, P. Schlagheck, D. Ullmo; Ann. Phys. **300** (2002), 88.

[2] E. Altmann, H. Kantz; Europhys. Lett. **78** (2007), 10008.

[3] J. Laskar; Physika D **67** (1993), 257.

DY 10.5 Tue 10:30 MA 001

Parameter-space for a dissipative Fermi-Ulam model — •Diego Fregolente Mendes de Oliveira — Institute for Multiscale Simulations - Friedrich-Alexander Universität - D-91052 - Erlangen - Germany

The parameter-space for a dissipative bouncing ball model under the effect of inelastic collisions is studied. The system is described by using a two-dimensional nonlinear area-contracting map. The introduction of dissipation destroys the mixed structure of phase space of the non-dissipative case leading to the existence of a chaotic attractor and attracting fixed points which may coexist for certain ranges of control parameters. We have computed the average velocity for the parameter space and we have made a connection with the parameter space based on the maximum Lyapunov exponent. For both cases we have found an infinite family of self-similar structures of shrimp-shape which correspond to the periodic attractors embedded in a large region which corresponds to the chaotic motion. The procedure is of broad interest and can be extended to many other different two dimensional area contracting models.

DY 10.6 Tue 10:45 MA 001

Coexistence of exponentially many chaotic spin-glass attractors — Yitzhak Peleg[1], Meital Zigzag[1], Wolfgang Kinzel[2], and •Ido Kanter[1] — [1]Department of Physics, Bar-Ilan University, IL-52900 Ramat-Gan, Israel — [2]Institute for Theoretical Physics, University of Wuerzburg, Am Hubland, DE-97074 Wuerzburg, Germany

chaotic network of size N with delayed interactions which resembles a pseudo-inverse associative memory neural network is investigated. For a load $\alpha = P/N < 1$, where P stands for the number of stored patterns, the chaotic network functions as an associative memory of 2P attractors with macroscopic basin of attractions which decrease with α. At finite α, a chaotic spin-glass phase exists, where the number of distinct chaotic attractors scales exponentially with N. Each attractor is characterized by a coexistence of chaotic behavior and freezing of each one of the N chaotic units or freezing with respect to the P patterns. Results are supported by large scale simulations of networks composed of Bernoulli map units and Mackey-Glass time delay differential equations.

DY 10.7 Tue 11:00 MA 001

Spin-orbital phase synchronization in the magnetic field-driven electron dynamics — •Levan Chotorlishvili and Jamal Berakdar — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg

We study the dynamics of an electron confined in a one-dimensional double quantum dot in the presence of driving external magnetic fields. The orbital motion of the electron is coupled to the spin dynamics by spin orbit interaction of the Dresselhaus type. We derive an effective time-dependent Hamiltonian model for the orbital motion of the electron and obtain a synchronization condition between the orbital and the spin dynamics. From this model we deduce an analytical expression for the Arnold tongue and propose an experimental scheme for realizing the synchronization of the orbital and spin dynamics.

15 min break

DY 10.8 Tue 11:30 MA 001

Reliable Dynamics in Boolean and continuous networks — •Eva Gehrmann[1], Tiago P. Peixoto[2], and Barbara Drossel[1] — [1]Institut für Festkörperphysik, TU Darmstadt — [2]Institut für Theoretische Physik, Universität Bremen

We compare continuous and Boolean dynamics of gene regulatory networks that have entirely reliable trajectories, i.e., the sequence of states in the Boolean model does not depend on the order in which nodes are updated. So far, little is known about general conditions under which a Boolean simplification captures correctly the dynamics in gene regulation networks. Previous research suggests that not the topology and size of a network determine the extent of agreement between Boolean and continuous models, but the features of the network. We investigate the dynamical behavior of networks that have entirely reliable trajectories in the Boolean model version, i.e., trajectories with Hamming distance 1 between subsequent states. We translate the Boolean model for gene activity into continuous dynamics for mRNA and protein concentrations using sigmoidal Hill functions and analyze the resulting time-series of hundreds of networks with different sizes and different lengths of the trajectories. For entirely reliable trajectories, we find perfect agreement between the Boolean and the continuous dynamics. In order to assess the importance of having reliable trajectories, we also use models where the average Hamming distance between subsequent states is larger than 1. A careful analysis reveals the reasons why the good agreement between the Boolean and the continuous dynamics is destroyed in many networks with larger Hamming distance.

DY 10.9 Tue 11:45 MA 001

Synchronization in mutually delay-coupled semiconductor lasers and its decay due to bubbling — •Konstantin Hicke[1], Jordi Tiana-Alsina[2], Xavier Porte[1], Miguel Soriano[1], M. Carme Torrent[2], Jordi Garcia-Ojalvo[2], and Ingo Fischer[1] — [1]Instituto de Fisica Interdisciplinar y Sistemas Complejos, IFISC (UIB-CSIC), Campus Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain — [2]Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Campus de Terrassa, Edif. GAIA, Rambla de Sant Nebridi s/n, Terrassa E-08222 Barcelona, Spain

Coupled semiconductor lasers are ideal testbeds to study synchronization properties of delay-coupled systems. At the same time they are promising for applications. An aspect which is therefore important is how synchronization can get lost. Here we present experimental results for the dynamics of two mutually coupled semiconductor lasers in a relay-coupling-configuration. We achieve excellent zero-lag chaos synchronization of the lasers' output intensities. Moreover, we demonstrate how the overall synchronization quality decreases with increasing pump current. We identify this to be due to an increase of the occurence of intermittent desynchronization events which we attribute to noise-induced bubbling. We point out the difference to global transverse instabilities of the synchronization and the resulting on-off intermittency. This is completed by a detailed analysis of the desynchronization events.

DY 10.10 Tue 12:00 MA 001

Global synchronisation of excitable units induced by network dynamics — •Claudio J. Tessone[1] and Damián H. Zanette[2] — [1]Chair of Systems Design, ETH Zürich. Kreuzplatz 5, CH-8032 Zürich, Switzerland — [2]Departamento de Física Estadística e Interdisciplinar, Centro Atómico Bariloche. R8400 S. C. de Bariloche, Argentina

In many cases of interest, the structure describing the interaction network underlying a given system evolves over time. However, its full –often complex– structure, becomes apparent only when seen over long time-scales, in many cases much larger than those associated with the internal dynamics of the elements represented by the nodes. Take a social network as a prototypic example: individuals can interact only with a very limited subset of their acquaintances over a given period of time. Then, over a limited interval, the network looks rather sparse. Despite of this, several dynamical processes are able to survive and spread though real-world networks, such as diseases and opinions. In this contribution, we study a sparsely connected network of excitable FitzHugh-Nagumo units (not subject to any kind of perturbation), in which the edges randomly rewire at a given rate. We show that a globally synchronised state can be induced solely by the network dynamics. If the rewiring rate is too slow or fast, no emergent dynamics appear, and the units rest in the fixed point of the dynamics. However, there exists an intermediate range of values of the rate of link recombination where all the units fire in a synchronised fashion. This shows that this phenomenon is not a trivial one induced by global coupling, but the outcome of an interplay between node and network dynamics.

DY 10.11 Tue 12:15 MA 001

Onset of Synchronization in Complex Networks of Noisy Oscillators — •Bernard Sonnenschein[1,2] and Lutz Schimansky-Geier[1,2] — [1]Institute of Physics, Humboldt University at Berlin, Newtonstr. 15, 12489 Berlin, Germany — [2]Bernstein Center for Computational Neuroscience, Philippstr. 13, 10115 Berlin, Germany

We investigate noisy Kuramoto oscillators on networks that are undirected and complex. Our problem allows to study the effects and the interplay of networks with a given degree distribution, diversity of oscillators and noise acting on the natural frequencies.

We derive the critical coupling strength for the onset of synchronization by approximating the complex network by a weighted fully connected network.

We find that the critical coupling strength is a product of two factors. The first one depends solely on the network topology, while the second factor is a function of the noise intensity and the diversity of the oscillators. Our result is applied to a dense small-world network model in order to provide numerical verification.

We obtain a satisfying agreement between simulations and theory for the critical coupling strength, regardless of whether we consider the dependencies on the topology or the dependencies on the diversity.

Only for a smaller number of edges in the network, the critical coupling strength is slightly overestimated by our approximation technique, but the functional dependencies can still be reproduced qualitatively.

DY 10.12 Tue 12:30 MA 001

Synchronized Cluster Formation in Coupled Laser Networks — Micha Nixon[1], Motti Fridman[1], Eitan Ronen[1], Asher Friesem[1], Nir Davidson[1], and •Ido Kanter[2] — [1]Weizmann Institute of Science, Dept. of Complex Systems, Rehovot, Israel — [2]Bar-Ilan University, Dept. of Physics, Ramat-Gan, Israel

We experimentally investigated networks of up to seven lasers with homogeneous bidirectional time-delayed coupling and established the following fundamental rules governing their synchronization state [1]. A network exhibits only two synchronized states: zero-lag synchronization, where all the lasers are synchronized to each other, occurs for networks with at least one odd numbered loop. Or sub- lattice synchronization, where the network splits into two synchronized clusters of alternating lasers that are not synchronized with each other, occurs for networks comprised only of even numbered loops. This implies that the synchronization state of the network is governed by a non-local phenomenon; hence, it cannot be deduced by decomposing the network into sub-structures that maintain their individual synchronization states.

Very recently we extended the experimental investigation of synchronized cluster formation to unidirectional coupled laser networks with a much larger number of lasers that also include heterogeneous coupling delay time [2].

[1] M. Nixon, et. al., Phys. Rev. Lett., 106, 22 (2011).
[2] M. Nixon et al., submitted (2011).

DY 10.13 Tue 12:45 MA 001

Measures for correlations and complexity based on exponential families — •Otfried Gühne[1], Sönke Niekamp[1], and Tobias Galla[2] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Str. 3, D-57068 Siegen — [2]Complex Systems and Statistical Physics Group, School of Physics and Astronomy, University of Manchester, Manchester M13 9PL, United Kingdom

Correlations between different parts of a physical system are ubiquitous in nature. Their characterization is crucial for the study of complex systems, but also interesting from the viewpoint of quantum information theory. To quantify such correlations, measures based on the notion of exponential families have been studied [T. Kahle *et al.,* Phys. Rev. E **79**, 026201 (2009)]. The basic element of this approach is to use the distance of a probability distribution to the thermal states of k-particle Hamiltonians as a measure of the correlations in the distribution.

For the case of classical probability distributions, we show that such measures are lacking some desirable properties of correlation measures. However, we propose a modified definition which can be used to overcome this problem [T. Galla *et al.,* arXiv:1107.1180]. In the quantum case, the probability distribution is replaced by a density matrix, but still the same type of correlation measures can be defined. We present an algorithm to compute such measures efficiently for quantum states. We also demonstrate that this approach can be used to show that certain relevant quantum states (such as the cluster states) cannot be approximated by ground states of two-body Hamiltonians.

DY 11: Glasses II (with CPP, talks by DY)

Time: Tuesday 10:00–12:30 Location: MA 004

DY 11.1 Tue 10:00 MA 004

The coupled energy landscape model — •Christian Rehwald and Andreas Heuer — Institut für Physikalische Chemie, Westfälische Wilhelms-Universität Münster, 48149Münster

While the dynamics of small glass-forming systems can be described by properties of the underlying potential energy landscape (PEL), this concept breaks down in large systems. Here we present the “coupled energy landscape model” (CLM) which extends the PEL description to macroscopic system by introducing a coupling mechanism between the PEL of elementary systems (ES).

First we use the distance dependence of structural relaxations after an initial reorganization in an iso-configurational ensemble of a non-equilibrium configuration. The results indicate the existence of a causal connection between successive events, which can be identified as dynamical coupling between ES.

In a next step we use different observables to extract coupling mechanisms and their strength in the CLM from MD simulations (of a binary mixture of LJ particles): Finite size effects of τ_α and the non-exponentiality parameter β_{KWW} are proving to be an appropriate measure for comparing the two dynamics. The CLM combines advantages of recently discussed models for the glass transition like facilitated spin models and the mosaic approach and can be used to understand principles of glassy dynamics like increasing τ_α and emergence of the growing dynamical length scale χ_4.

DY 11.2 Tue 10:15 MA 004

Glassy dynamics on the atomic scale measured with XPCS — •Manuel Ross[1], Michael Leitner[1,2], Markus Stana[1], and Bogdan Sepiol[1] — [1]Department of Physics, University of Vienna, 1090

Vienna, Austria — [2]Physics Department E13, Technical University of Munich, 85747 Garching, Germany

The world of solids can be divided into crystals and amorphous materials. One of physics' unsettled questions is the dynamic behavior of these amorphous materials, especially that of glasses. In our group, we developed a new method for observing dynamics on the atomic level [1]. Utilizing the most brilliant X-rays generated by high energy synchrotron sources and measuring in the diffuse regime of scattering, the principle of photon correlation spectroscopy can be extended to the sub-nanometer range. We currently apply our method to glasses in order to shed light on the processes which govern glassy dynamics. In particular, we study lead and silicate glasses, where the network is built of tetrahedral structures. I will present our recent results obtained from measurements at ESRF and PETRA III and the consequences for our view on the atomic dynamics of glasses.

[1] M. Leitner, B. Sepiol, L. M. Stadler, B. Pfau, and G. Vogl, Atomic diffusion studied with coherent X-rays, Nature Mat. 8, 717 (2009).

DY 11.3 Tue 10:30 MA 004

Computer simulation of micro-rheology in glass-forming systems — David Winter[1] and •Juergen Horbach[2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, 55099 Mainz, Germany — [2]Institut für Theoretische Physik II, Heinrich Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany

In the last ten years, micro-rheology has been established as a new tool to probe the non-linear response of soft-matter systems to external fields. In a micro-rheological experiment,single particles are pulled through a viscous medium by a constant or oscillatory force using, e.g., optical tweezers. In the work presented in this talk, the single-particle response to a constant external force of varying strength is investigated for a glass-forming Yukawa mixture using molecular dynamics computer simulation. Beyond linear response, a scaling regime is found where a force-temperature superposition principle of a Peclet number holds. In the latter regime, the diffusion dynamics perpendicular to the force can be mapped on the equilibrium dynamics in terms of an effective temperature whereas the diffusion coefficient parallel to the force does not exist. This behavior is associated with a hopping motion of the pulled particle from cage to cage and can be qualitatively understood by a simple trap model, as proposed by Bouchaud and coworkers.

DY 11.4 Tue 10:45 MA 004

Statistical analysis of the non-linear dynamics of a supercooled model fluid under a microrheological perturbation — •Carsten Schroer[1,2] and Andreas Heuer[1,2] — [1]Institut für physikalische Chemie, Münster, Germany — [2]Graduate School of Chemistry, Münster, Germany

In our approach we regard the complex dynamics of glass-forming systems as a stochastic process on the potential energy landscape (PEL). Via computer simulations it is possible to map the continuous dynamics onto a hopping motion between the corresponding inherent structures of the system. We find mesoscopic regions (metabasins) in the PEL where the system is located for long times so that dynamics is mainly determined by the transitions between those metabasins. These discrete processes allow us to describe the dynamics in terms of a continuous time random walk.

This approach is of particular interest when including a microrheological perturbation via non-equilibrium molecular dynamic simulations. We report how linear and non-linear responses translate into the continuous time random walk properties of the system. Furthermore we show what consequences for the pathway of the system in its PEL arise by the application of a microrheological perturbation. We discuss these effects in terms of a rejuvenation scenario.

DY 11.5 Tue 11:00 MA 004

Glass structure with well defined thermal history and glassy dynamic — •Christoph Scherer[1,2], Friederike Schmid[1], and Martin Letz[2] — [1]Institut fuer Physik, Johannes-Gutenberg Univ. Mainz, Staudingerweg 9, 55099 Mainz — [2]Schott AG, Hattenbergstr. 10, 55122 Mainz

Glasses have a huge range of applications, however, they are still theoretically not well understood. Also experimental access to the structure of glasses is limited. This motivates the study of glass systems by means of computer simulations. In this work a set of glass structures with well defined thermal history is generated on the computer. Each glass structure is created by gradually cooling down a set of 100-200 atoms by means of a molecular dynamics simulation as long as the system still can be equilibrated in reasonable simulation time. Afterwards, it is quenched down to room temperature and the resulting atom coordinates and velocities are stored. They are used as a starting point for a quantum-mechanical relaxation by means of density functional theory. Then the vibrational spectrum is determined and compared to experimental results. From the vibrational spectrum a set of thermodynamic quantities, as the temperature dependent specific heat, are obtained and compared to measured data. First successful tests on the model glass former SiO2 are presented.

DY 11.6 Tue 11:15 MA 004

Microscopic picture of the beta-wing in simulated Ni0.5Zr0.5 melt — •Helmar Teichler — Inst. f. Materialphysik, Univ. Göttingen, Göttingen, Germany

The beta-wing is found in a large variety of liquids as an additional contribution to the susceptibility on the high frequency flank of the alpha peak. The underlying microscopic processes are not well understood so far. Regarding this, we have analyzed simulation data of a Ni0.5Zr0.5 model, using as main tool the fraction of un-displaced particles (FUDP). In the alpha and beta regime, the FUDP is a nearly linear mapping of the incoherent intermediate scattering function (ISF) (for suitably q) (H. Teichler, PRL, 107,067801 (2011)). Hence, the susceptibilities of FUDP and ISF display nearly identical alpha peak and beta-wing. The analysis unambiguously shows that this susceptibility is due to temporal accumulation of incoherent short-ranged displacement processes, where the stretched exponential behavior reflects "structure conserving correlations" in the accumulation process. Accordingly, the beta-wing reflects stronger structure restoring effects in the wing range than in the rest of the alpha regime.

DY 11.7 Tue 11:30 MA 004

Glass form factors in confined geometry — •Simon Lang[1], Vitalie Botan[2], Martin Oettel[2], Rolf Schilling[2], and Thomas Franosch[1] — [1]Friedrich-Alexander Universität, Erlangen, Germany — [2]Johannes Gutenberg-Universität, Mainz, Germany

Supercooled liquids embedded in complex geometries exhibit an intriguing interplay between particle interaction and incommensurability effects. Recently, the mode-coupling theory (MCT) of the glass transition was elaborated for a symmetric hard-wall confinement, where the glass-transition line reveals a striking re-entry phenomenon by varying the wall-to-wall separation [1]. A subtle point of the mathematical structure of these MCT equations is the emergence of two relaxation channels, which arise from a splitting of the current into a parallel and perpendicular direction with respect to the walls. Here, we present the glass form factors evaluated at the critical point for several distances. These arrested parts of the intermediate scattering function yield information about the structural arrangement of the particles in the confined glass state. We show, that the structure changes drastically upon varying the wall separation and the hallmarks of the phase diagram for confined liquids are reflected in the glass form factor. We demonstrate that the MCT equations for the glass form factor in confinement can be solved by a convergent iteration. From a generalized covariance property, the maximum principle for the glass form factors holds also for the MCT for confined liquids.

[1] S. Lang, V. Boţan, M. Oettel, D. Hajnal, T. Franosch, and R. Schilling, Phys. Rev. Lett.105 125701 (2010).

DY 11.8 Tue 11:45 MA 004

Transient stresses and MSDs in sheared dispersions as described by mode-coupling theory (MCT) — •Christian Peter Amann and Matthias Fuchs — Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany

Sheared viscoelastic media exhibit a stress overshoot between elastic and plastic regime, i.e. a maximum in the shear stress vs strain plot after switching on a constant shear rate. This maximum characterizes the transient evolution between equilibrium and steady state. A way to model such overshoots is the $F_{12}^{(\dot{\gamma})}$ model, a schematic model in MCT to describe glass forming liquids. This approach is tested by comparing results with various rheological experiments. Flow curves, linear- and non-linear stress response, and stress-strain curves can be fitted consistently with the same model [1,2]. Within microscopic MCT the stress overshoot is identified as negative dip in the dynamic stress autocorrelation function [3].

This mechanism also causes super-diffusive colloid motion [3]. We connect shear stress and colloidal MSD via a generalized Stokes–Einstein relation and compare shear–stress and MSD simulations to define a characteristic strain determining maximum shear stress and onset of superdiffusion.

[1] M. Siebenbürger et al., *J. Rheol.* **53**, 707–726 (2009)
[2] J.M. Brader et al., *Phys. Rev. E* **82**, 061401 (2010)
[3] J. Zausch et al., *J. Phys.: Condens. Matter* **20**, 404210 (2008)

DY 11.9 Tue 12:00 MA 004

Probing Spectral Diffusion Theory in Glasses Through Polarization Echo Measurements — •Gudrun Fickenscher, Christian Schötz, Paul Fassl, Masoomeh Bazrafshan, Manfred von Schickfus, Andreas Fleischmann, and Christian Enss — Kirchhoff Institute, Heidelberg University, Germany

Many low temperature properties of glasses can be well described by the standard tunnelling model. It assumes an ensemble of isolated tunnelling systems (TS) with a broad distribution in energy splitting and asymmetry. They can couple resonantly to electric fields and can therefore be probed by polarization echo measurements. When looking at dynamic properties of glasses, however, the influence of the TSs in the surrounding of the resonantly probed TSs has to be taken into account. Spectral diffusion theory* assumes that transitions in thermally excited TSs change the local fields at the positions of the resonant TSs, thus changing their energy splitting and phase. This affects the decay behaviour of the polarization echo amplitude with respect to the delay time.

We have performed different types of polarization echo measurements including 2-pulse echoes which show an almost pure T_2 decay and 3-pulse echoes which are more sensitive to T_1 processes. The setup allows for measurements with very long delay times of several milliseconds. We calculated the decay in echo amplitude within the framework of the spectral diffusion theory and compared the results.

* J.L. Black, B.I. Halperin, Phys. Rev. B **16** (1977), 2879.

DY 11.10 Tue 12:15 MA 004

Dielectric polarization noise and permittivity - A fluctuation-dissipation analysis during the curing of an epoxy resin — Clemens Hassel, •Andreas Reiser, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

Dielectric spectroscopy as a driven method combined with non-driven dielectric noise spectroscopy is a powerful experimental method for studying the fluctuation-dissipation theorem experimentally. We apply both methods during the curing process of the epoxy resin Epon 828 with n-butylamine. Setting the sample temperature properly allows controlling the time scale of curing. We measure in the temperature range between 293 K and 303 K at fixed temperatures. During curing the Epon-n-butylamine mixture undergoes a chemically induced glass transition. We analyze the validity of the fluctuation-dissipation theorem and calculate an effective temperature for this system.

DY 12: Joint focus session (with BP): Statistics of Cellular Motion

This topical session brings together theoretical and experimental researchers working on statistical descriptions of cell motility, which is an emerging theme in the rapidly growing field of cell motility. (Organizers Carsten Beta, Peter Dieterich, Rainer Klages and Lutz Schimansky-Geier)

Time: Tuesday 9:30–13:30 Location: H 1028

Topical Talk DY 12.1 Tue 9:30 H 1028

Data-driven modeling of cell trajectories: a do-it-yourself kit — •Henrik Flyvbjerg — DTU Nanotech, Kongens Lyngby, Denmark

Resent results in data-driven modeling of cell trajectories are reviewed. A do-it-yourself toolkit is presented. Technical points are discussed, such as how to glean mathematical properties of a model-to-be-found from appropriate model-independent experimental statistics, and how such statistics are affected by finite sampling frequency of time-lapse recordings and experimental errors on recorded positions.

Topical Talk DY 12.2 Tue 10:00 H 1028

The statistics of eukaryotic chemotaxis — •Eberhard Bodenschatz — MPI Dynamics and Self-Organization, Goettingen, Germany

The directed motion of eukaryotic cells in a chemoattractant gradient depends on the the steepness of the gradient as well as the average concentration surrounding the cell. It was recently theoretically predicted that for a given situation the chemotactic efficacy is determined by the stochastic fluctuations of a two step process: first the binding of the signaling molecule to the transmembrane receptor and second the intracellular unbinding of a second messenger. It was suggested that the signal to noise ratio of this two stage process is sufficient to explain the chemotactic behavior. In this talk we will first introduce eukaryotic chemotaxis and the experimental micro-fluidic system for controlled chemical signals. Then we shall present the data on the random directed motion of cells and will describe it with a 2D Langevin equation. Then we show that the stochasticity of the two step process can indeed describe the experimentally observed behavior.

Topical Talk DY 12.3 Tue 10:30 H 1028

Dynamics of directed cell migration — •Albrecht Schwab[1], Otto Lindemann[1], and Peter Dieterich[2] — [1]University of Münster, Germany — [2]University of Dresden, Germany

Directed migration (chemotaxis) is the prerequisite for an efficient immune defense. The chemical signal is transduced to the cell migration machinery via complex intracellular signaling cascades that also include the activation of plasma membrane $Ca2+$ channels of the TRPC family. Chemotaxis involves a cellular motor for migration and a steering mechanism. Here, we aim to determine which of these two components are controlled by TRPC channels. Their contribution is assessed with time-lapse video microscopy of single neutrophils from wildtype and TRPC knockout mice exposed to chemoattractants. Since raw velocities or straightness indices calculated from the experimental cell paths provide only a coarse interpretation of the migratory behavior, we analyze all data within the concept of stochastic processes. The cell is regarded as an object driven by internally correlated stochastic forces and external fields generated by chemoattractants. Anomalous properties that we previously identified in cells migrating without external stimuli and described with a fractional Klein-Kramers equation are maintained during chemotaxis. This enables a modeling based quantification of correlations and allows to disentangle the influence of the chemoattractants on the motor strength (thermal velocity) and directed migration (drift) of the cells under different conditions. Our statistical analyses show that TRPC channels are primarily involved in controlling the steering mechanism of chemotacting neutrophils.

Topical Talk DY 12.4 Tue 11:00 H 1028

Medley swimming of sleeping sickness parasites — •Vasily Zaburdaev[1], Sravanti Uppaluri[2], Thomas Pfohl[3], Markus Engstler[4], Rudolf Friedrich[5], and Holger Stark[6] — [1]Harvard University, Cambridge, USA — [2]Max-Planck-Institute for Dynamics and Self-Organization, Göttingen, Germany — [3]University of Basel, Basel, Switzerland — [4]University of Würzburg, Würzburg, Germany — [5]University of Münster, Münster, Germany — [6]Technical University of Berlin, Berlin, Germany

Though cell locomotion has been examined almost since the discovery of the cell itself, advances in microscopy and biochemical studies have paved the way to a more fundamental understanding of cell motility. This work is a detailed, quantitative characterization of trypanosome motility. Trypanosomes, parasites responsible for deadly disease in humans and cattle, swim with the aid of an appendage called a flagellum. The flagellum, produces rapid undulatory movements that result in cell locomotion. We followed single trypanosomes in a homogeneous environment and found that cells that swim faster also exhibit stronger fluctuations in velocity. Statistical analysis allowed us to develop a mathematical model that could reproduce the diverse trajectories followed by the trypanosomes. Finally, we were able to show that the rapid movements of the body (with time scales on the order of 0.1s) are a result of an active process and thus cannot be described as simple thermal fluctuations. On the whole, such studies provide insight into basic mechanisms of motility, allow for modeling of cell movement, and may eventually even provide design ideas for artificial microswimmers.

15 min break

DY 12.5 Tue 11:45 H 1028

Describing Run and Tumble Motion with Alternating Random Walks — •Felix Thiel, Lutz Schimansky-Geier, and Igor M. Sokolov — Institut für Physik der Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin

Run and tumble motion is the motile behaviour of flagellated bacteria like E.Coli. Much effort has been made in order to understand and describe such motion. Continuous time random walks (CTRW) are a common tool for description, but lack the possibility of incorporating different kinds of motion. In order to fill this gap, we present a modification of the usually considered CTRW: the alternating random walk. We explicitly distinguish between the run and the tumble phase. By using the techniques of CTRW – integral transforms and asymptotic analysis – we are able to obtain the short-time as well as the long-time behaviour of the mean squared displacement of the process. The main free parameters of the process governing the diffusive behaviour are the waiting-time-PDFs describing the dwelling time in run resp. tumble mode. It is shown that models constructed as above may exhibit a transition in diffusive behaviour from normal to superdiffusion and a change of the effective diffusion coefficient. They may thus be suitable to describe other situations which are known for those phenomena.

DY 12.6 Tue 12:00 H 1028

Swimming of microorganisms in a microchannel flow. — •Adam Wysocki, Roland G. Winkler, and Gerhard Gompper — Theoretical Soft Matter and Biophysics, Institute of Complex Systems and Institute for Advanced Simulation, Forschungszentrum Jülich

We consider an active suspension – motile microorganisms dispersed in a fluid – under flow in a microchannel. We use a coarse-grained model of an active suspension, where the microorganisms are modeled as spherical particles with a prescribed tangential surface velocity, and the fluid is described by multiparticle collision dynamics approach, a particle-based, mesoscopic simulation method, which includes thermal fluctuations. Our model of a swimmer can easly be tuned to be a puller or a pusher, which generate thrust in the front or at the back of the body, respectively. At low swimmer concentrations, far from the walls and for external flow fields u small compared to the propulsion velocity U_0, puller and pusher swim upstream following on average a sinusoidal trajectory. Near the walls, where hydrodynamic interactions are significant, pullers and pushers show a qualitatively different behaviour. Individual pushers swim upstream near the wall for $U_0/u > 1$, while pullers swim downstream for $U_0/u \gg 1$ and change to upstream swimming with increasing flow field u. The collective behaviour at higher concentrations of microorganisms will be discussed.

DY 12.7 Tue 12:15 H 1028

Self-propelled rod-like microswimmers near surfaces — •Kristian Marx and Gerhard Gompper — Theoretical Soft Matter and Biophysics, Institute of Complex Systems, Forschungszentrum Jülich

Self-propelled microswimmers (e.g. sperm, E. coli and the alga Chlamydomonas) are biological organisms that propel themselves through fluid. In future applications, microswimmers may also be used as biosensors on lab-on-a-chip devices. They can be classified as having *pusher* or *puller polarity*, which are driven from the rear or the front, respectively. We study the behavior of a general polar rod model at high swimmer densities in three dimensions, in particular close to walls, including hydrodynamics and volume-exclusion interactions. We employ hydrodynamics simulations using a mesoscale particle based technique (*multi-particle collision dynamics*) implemented on GPU hardware. The swimmer behavior is found to strongly depend on the swimmer polarity: Pushers experience parallel alignment with the walls and strongly aggregate near them. Due to mutual hydrodynamic attraction the rods form motile clusters at the walls. Interacting clusters can form swirls, destroying long-range nematic order. Pullers aggregate into giant immotile clusters that span the entire system at high densities. While they are overall isotropic, the puller clusters show a typical hedgehog structure at the walls, with most of the swimmers pointing towards the walls. Finally, *unpolar driven* rods interact only weakly via hydrodynamics and show an isotropic-nematic phase transition at critical densities much lower than passive rod systems.

DY 12.8 Tue 12:30 H 1028

Collective Dynamics of swimming bacteria and surface attached clusters during biofilm formation — •Matthias Theves and Carsten Beta — Universität Potsdam, Potsdam, Germany

Biofilms (BFs) are communities of sessile bacteria, embedded in an extracellular polymeric structure (EPS), which form at solid-liquid or liquid- air interfaces. We use biocompatible microfluidic channels and high speed time lapse microscopy to study the recruitment of cells from the bulk fluid to a glass surface. During this early stage of BF-formation, bacteria from the swimming phase coexist with surface attached cells that cluster together and form the cores of growing colonies. We analyze the growth dynamics of both populations. After a continuous increase in cell density and cluster size, we observe a sudden increase in the number of swimming cells. Furthermore, we analyze the random walk of isolated swimmers and perform a statistical analysis that allows us to identify changes in the migration patterns of swimming cells in the presence of different obstacles in the microchannel and during experiments with different medium availability.

DY 12.9 Tue 12:45 H 1028

Rotationally induced polymorphic transitions of a bacterial flagellum — A full model of swimming *Rhodobacter sphaeroides* — •Reinhard Vogel and Holger Stark — Institute of Theoretical Physics, TU Berlin

The bacterium *Rhodobacter sphaeroides* swims by rotating a helical filament also called flagellum. The filament is driven by a rotary motor. Depending on the speed of the motor, the flagellum assumes different configurations characterized by its pitch and radius (polymorphism). If the motor stops, the flagellum relaxes into a coiled form with large radius and small pitch, whereas if the motor runs it assumes a helical state with large pitch better suited for swimming. Due to the switch between running and stopping, the bacterium changes its direction randomly.

The bacterial flagellum consists of three parts; the rotary motor embedded in the cell membrane, a short proximal hook that acts as a universal joint and couples the motor to the third part, the long helical filament. The helical shape of the filament converts rotational motion into a thrust force that pushes a bacterium forward. We present our approach to mimic the rotary motor and hook within a continuum model of the flagellum. We use the elastic theory for flagellar polymorphism, developed in Ref. [1], to investigate how an applied motor torque induces a transition between two polymorphic configurations. We attach the bacterial flagellum to a load particle and thereby model the locomotion of the bacterium *Rhodobacter sphaeroides*.

[1] R. Vogel and H. Stark, Eur. Phys. J. E **33**, 259–271 (2010).

DY 12.10 Tue 13:00 H 1028

Hydrodynamic Simulation of Bacteria Swimming — •Shang Yik Reigh, Roland G. Winkler, and Gerhard Gompper — Theoretical Soft Matter and Biophysics, Institute of Complex Systems and Institute for Advanced Simulation, Forschungszentrum Juelich, 52425 Juelich

Locomotion of bacteria such as E. coli or Salmonella is achieved by rotation of helical flagella, which are randomly distributed on the cell body. A directional running motion is attained by bundle formation of multiple flagella, while tumbling motion is achieved by the reverse rotation of one of the flagella. Alternating running and tumbling phases allow the bacteria to perform a directed random walk, and play an important role in their chemotaxis. During bacterial swimming, the pitch and the radius of flagella are changed (polymorphic transformations) and the cell body counter-rotates against the flagella to conserve angular momentum. To gain insight into the bacterial swimming behavior, hybrid mesoscale simulations are performed, which combine molecular dynamics simulations for the bacterium with the multiparticle collision (MPC) method for the solvent. The flagella are constructed by a sequence of mass points interacting by bond, bending, and torsional potentials. Such a model can efficiently be coupled to the MPC fluids. Results are presented for the synchronization and the bundle formation of several flagella. The synchronization and bundling times are analyzed in terms of the applied torque, the separation distances, and the number of flagella. The role of counter-rotating cell body for synchronization and bundling will be discussed.

DY 12.11 Tue 13:15 H 1028

Pili-induced clustering of *Neisseria gonorrhoeae* bacteria

— •Johannes Taktikos[1,2], Vasily Zaburdaev[2], Nicolas Biais[3], David A. Weitz[2], and Holger Stark[1] — [1]Technische Universität Berlin — [2]Harvard University, USA — [3]Columbia University, USA

The attachment of *Neisseria gonorrhoeae* bacteria, the causative agent of the gonorrhea disease, to human epithelial cells constitutes the first step of colonization. The attachment of *N. gonorrhoeae* to surfaces or other cells is primarily mediated by filamentous appendages, called type IV pili. Cycles of elongation and retraction of these pili are responsible for a common form of bacterial motility called twitching motility which allows the bacteria to crawl over surfaces. Experimentally, *N. gonorrhoeae* cells initially dispersed over a surface agglomerate into round microcolonies within hours. It is so far not known whether this clustering is driven entirely by the pili dynamics or if chemotactic interactions are needed. Thus, we investigate whether the agglomeration may stem solely from the pili-mediated attraction between cells. By developing a model for pili-taxis, we try to explain the experimental measurements of the mean cluster size, number of clusters, and area fraction covered by the cells.

DY 13: Nonlinear Stochastic Processes

Time: Tuesday 14:15–15:15 Location: MA 004

DY 13.1 Tue 14:15 MA 004

The Nature and Perception of Fluctuations in Human Musical Rhythms — Holger Hennig[1,2,3], Ragnar Fleischmann[1], Anneke Fredebohm[4], York Hagmayer[5], Jan Nagler[1,2], Annette Witt[1,6], Fabian J. Theis[1,6,7], and •Theo Geisel[1,2,6] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen — [2]Institute for Nonlinear Dynamics, University of Göttingen — [3]Harvard University, Cambridge, MA, USA — [4]Institute of Psychology, University of Göttingen — [5]Kings College, London, UK — [6]BCCN, Göttingen — [7]Helmholtz Zentrum München

Although human musical performances represent one of the most valuable achievements of mankind, the best musicians perform imperfectly. Musical rhythms are not entirely accurate and thus inevitably deviate from the ideal beat pattern. Nevertheless, computer generated perfect beat patterns are frequently devalued by listeners due to a perceived lack of human touch. Professional audio editing software therefore offers a humanizing feature which artificially generates rhythmic fluctuations. However, the built-in humanizing units are essentially random number generators producing only simple uncorrelated fluctuations.

Here, for the first time, we establish long-range fluctuations as an inevitable natural companion of both simple and complex human rhythmic performances [1]. Moreover, we demonstrate that listeners strongly prefer long-range correlated fluctuations in musical rhythms. Thus, the favorable fluctuation type for humanizing interbeat intervals coincides with the one generically inherent in human musical performances.

[1] Hennig et al., PLoS ONE, 6, e26457 (2011)

DY 13.2 Tue 14:30 MA 004

Phase separation of binary mixtures in thin films: Effects of an initial concentration gradient across the film — •Prabhat K. Jaiswal[1,2], Kurt Binder[1], and Sanjay Puri[2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, D-55099 Mainz, Germany — [2]School of Physical Sciences, Jawaharlal Nehru University, New Delhi - 110067, India

We study the kinetics of phase separation of a binary (A,B) mixture confined in a thin film of thickness D by numerical simulations of the corresponding *time-dependent Ginzburg-Landau* model. The initial state consisted of 50% A : 50% B with a concentration gradient across the film, i.e., the average order parameter profile is $\Psi_{\rm av}(z,t=0) = (2z/D-1)\Psi_g$, $0 \le z \le D$, for various choices of Ψ_g and D. The equilibrium state consists of coexisting A-rich and B-rich domains separated by interfaces oriented perpendicular to the surfaces. However, for sufficiently large Ψ_g, a metastable layered state is formed with a single interface parallel to the surfaces. This phenomenon is explained in terms of a competition between domain growth in the bulk, and *surface-directed spinodal decomposition* that is caused by the gradient. Thus gradients in the initial state can stabilize thin-film morphologies which are not stable in full equilibrium. This offers interesting possibilities as a method for preparing novel materials.

DY 13.3 Tue 14:45 MA 004

Stochastic data analysis for in-situ damage analysis — •Philip Rinn, Joachim Peinke, Hendrik Heisselmann, and Matthias Wächter — ForWind – Center for Wind Energy Research, Institute of Physics, University of Oldenburg

A new method how to analyze the elastic features of a mechanical structure under turbulent excitation is presented. One limitation of common approaches is that noisy excitation of the structure makes it harder to detect changes reliably, because peaks in the frequency spectrum are broadened due to the noise and changes can not be detected precisely. We use an in-situ approach to look at the dynamical behavior of the system and to analyze damages due to its changing of the systems dynamics. With methods from stochastic data analysis we separate the stochastic part from the deterministic part of the system. In particular the Langevin equation from undamaged and damaged beam structures in turbulent air inflow is reconstructed. We show that the slope of the drift, that is the determinism of the system, changes with increasing damage and compare the results with changes in eigenfrequencies.

DY 13.4 Tue 15:00 MA 004

When it pays off to pay tax: Insights from coupled multiplicative stochastic processes — Jan Lorenz[1,2] and •Frank Schweitzer[1] — [1]Chair of Systems Design, ETH Zurich, Kreuzplatz 5, 8032 Zurich, Switzerland — [2]Center for Social Science Methodolgy, Carl von Ossietzky University Oldenburg, Ammerlander Heerstr. 114 - 118, 26129 Oldenburg, Germany

We demonstrate by mathematical analysis and systematic computer simulations that taxation and redistribution of wealth can lead to sustainable growth of wealth in a society. The wealth dynamics of each agent is described by a stochastic multiplicative process which, in the long run, leads to the destruction of individual wealth and the extinction of the society. When this lossy process is combined with a taxation mechanism, where some proportion of wealth is collected by a government, which further reduces a fraction as costs for administration. The remaining public good is equally redistributed to all agents. We derived conditions for under which the destruction of wealth can be turned into sustainable growth, despite the losses from the random growth process and despite the administrative costs.

DY 14: Joint focus session: Nonlinear Dynamics of the Heart

Time: Wednesday 9:30–12:00 Location: MA 001

Invited Talk DY 14.1 Wed 9:30 MA 001

Modelling Excitation Contraction Coupling — •Martin Falcke — Max Delbrück Centrum für Molekulare Medizin Berlin

We present an efficient but detailed approach to modelling Ca^{2+}-induced Ca^{2+} release in the diadic cleft of cardiac ventricular myocytes. We developed a spatial resolved Ca^{2+} release unit (CaRU), consisting of the junctional sarcoplasmic reticulum and the diadic cleft. Individaul channels are modelled by Markov chains. By taking advantage of time scale seperation, the model could be finally reduced to only one ordinary differential equation for describing Ca^{2+} fluxes and diffusion. Additionally the channel gating is described in a stochastic way. The resulting model is able to reproduce experimental findings like the gradedness of SR release, the voltage dependence of ECC gain and typical spark life time.

Invited Talk DY 14.2 Wed 10:00 MA 001

Modeling of electrical and mechanical function of the heart — •Alexander Panfilov — Department of Physics and Astronomy, Gent University, Krijgslaan 281, S9, 9000 Gent, Belgium

Cardiac arrhythmias and sudden cardiac death is the leading cause of death accounting for about 1 death in 10 in industrialized countries. Although cardiac arrhythmias has been studied for well over a century, their underlying mechanisms remain largely unknown. One of the main problems in studies of cardiac arrhythmias is that they occur at the level of the whole organ only, while in most of the cases only single cell experiments can be performed. Due to these limitations alternative approaches such as mathematical modeling are of great interest. From mathematical point of view excitation of the heart is described by a system of non-linear parabolic PDEs of the reaction diffusion type with anisotropic diffusion operator. Cardiac arrhythmias correspond to the solutions of these equations in form of 2D or 3D vortices characterized by their filaments. In my talk I will briefly report on main directions of our research, such as development of virtual human heart model, and study organization of ventricular fibrillation due to dynamical instabilities in cardiac tissue and due to tissue heterogeneity. I will also report on modeling mechano-electric feedback in the heart using reaction-diffusion mechanics systems and ventricular fibrillation mechanisms due to deformation of cardiac tissue.

Invited Talk DY 14.3 Wed 10:30 MA 001

Mechanisms for calcium alternans — •Blas Echebarria, Enric Alvarez-Lacalle, Carlos Lugo, Angelina Peñaranda, and Inma R. Cantalapiedra — Departament de Física Aplicada, Universitat Politècnica de Catalunya, 44-50 Av. Dr. Marañón, 08028 Barcelona, Spain

Alternans is a well-known cardiac pathology, in which the duration of the action potential (AP) alternates at consecutive beats. Due to its proarrhythmic effects it is important to understand the mechanisms underlying its genesis. It has been amply studied the case where alternans appears due to a steep relationship between the duration of an action potential and the time elapsed since the end of the previous AP. However, now it is widely accepted that alternans often appears due to instabilities in the dynamics of intracellular calcium cycling (itself an important messenger for the contraction of the cell). This instability can be due to a steep relationship between the amount of calcium released to the cytosol, and the calcium loading of the sarcoplasmic reticulum (SR), but also due to a slow recovery of the channels that regulate the release from the SR.

Invited Talk DY 14.4 Wed 11:00 MA 001

Synchronization as a mechanism of chaos control; Applications to cardiac arrhythmias. — •Flavio H. Fenton[1], Stefan Luther[1,2], Philip Bittihn[2], Daniel Hornung[2], Eberhard Bodenschatz[2], and Robert F. Gilmour Jr[1] — [1]2Department of Biomedical Sciences, Cornell University, Ithaca, New York, USA — [2]1Max Planck Institute for Dynamics and Self-Organization, Goettingen, Germany

The heart is an excitable system, with electrical waves propagating in a coordinated manner to initiate a mechanical contraction. In pathologic states, normal electrical wave propagation can be disrupted, resulting in the development of spiral and scroll waves that repetitively excite the tissue. These waves are often unstable and break into multiple waves, a chaotic state that underlies cardiac fibrillation.

In this talk, we will discuss experimental and theoretical approaches for the control and termination of arrhythmias using low energy pulses. We will show how naturally occurring discontinuities in cardiac tissue conductivity can produce internal electrical activations following an electric field and how this *virtual electrode activations* can be used to synchronize and terminate arrhythmias with just 10% the energy of a standard defibrillation shock. Numerical simulations as well as experimental data from in vivo experiments will be presented along with a theory for the mechanism.

Invited Talk DY 14.5 Wed 11:30 MA 001

Cardiac dynamics from a nonlinear system's perspective - from basic science to applications — •Stefan Luther — Max Planck Institute for Dynamics and Self-Organization, Goettingen, Germany — Department of Biomedical Sciences, Cornell University, Ithaca, NY

Self-organized complex spatial-temporal dynamics underlies cardiac arrhythmias, a significant cause of mortality and morbidity worldwide. The term dynamical disease was coined, suggesting that they can be best understood from a dynamical system's perspective. The systematic integration experimental data from sub-cellular, cellular, tissue, and organ level to the in-vivo organism into mathematical models is key to the understanding of this complex biological system. The talk will provide an introduction to the biophysics and nonlinear dynamics of the heart, and discuss mechanisms that induce, sustain, and control life-threatening cardiac arrhythmias.

DY 15: Statistical Physics far from equilibrium

Time: Wednesday 9:30–13:30 Location: MA 004

Invited Talk DY 15.1 Wed 9:30 MA 004

Fluctuations and State Variables in Driven Granular Materials — •Karen Daniels — Dept. of Physics, North Carolina State University, Raleigh, NC, USA — MPI for Dynamics and Self-Organization, Göttingen

Statistical mechanics has provided a powerful tool for understanding the states of thermodynamic matter, and it is intriguing to investigate whether these successes are also relevant to non-equilibrium systems such as granular materials. I will describe experiments on a two-dimensional dense granular gas of disks suspended on a horizontal air table and agitated at the boundaries. We measure both bulk and particle-scale dynamics, and find a number of thermal-like behaviors including diffusive dynamics, a granular Boyle's law with a van der Waals-like equation of state, and energy equipartition for rotational and translational degrees of freedom. However, the scarcity of free volume provides a crucial control on the dynamics, and each of the above thermal-like behaviors is accompanied by interesting caveats.

DY 15.2 Wed 10:00 MA 004

Spin Glass to Ferromagnet: Ageing Simulations on GPUs — •Markus Manssen[1], Martin Weigel[2], and Alexander K. Hartmann[1] — [1]Institut für Physik, Carl von Ossietzky Universität Oldenburg, Germany — [2]Applied Mathematics Research Centre, Coventry University, England

The dynamics of spin glasses, frustrated magnetic systems, have been extensively studied [1] with computer simulations [2]. We broaden our view to the phase transition to the ferromagnet with the aid of Graphics Processing Units (GPUs) for long time simulations [3]. We focus on the three-dimensional binary Edwards-Anderson model and examine spatial and temporal correlations trying to explain them in terms of a growing dynamical correlation length.

[1] Naoki Kawashima and Heiko Rieger. Recent Progress in Spin Glasses. In Hung T. Diep, editor, *Frustrated Spin Systems*, pages 491–596. World Scientifc, 2004.

[2] Alexander K. Hartmann, *Practical Guide to Computer Simulations*, World Scientific, 2009

[3] Martin Weigel. Simulating spin models on GPU. *Computer Physics Communications*, 182(9): 1833–1836, 2010.

DY 15.3 Wed 10:15 MA 004

Microscopic Scattering Theory for Interacting Bosons in a Random Potential — Tobias Geiger, •Thomas Wellens, and Andreas Buchleitner — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

We microscopically derive a theory for scattering of N atoms – with all atoms initially prepared in the same single-particle momentum eigenstate – from a three dimensional random disorder potential in the presence of two-body interactions. Starting from an exact diagrammatic expansion of the N-particle scattering amplitude, we identify those combinations of diagrams which – in the case of a weak random potential (mean free path much larger than wavelength) – survive the disorder average, and sum up the remaining series of ladder and crossed diagrams non-perturbatively in the strength of the particle-particle interaction [1]. We show that the latter leads to a relaxation of the individual particles' energies towards a Maxwell-Boltzmann distribution as the particles diffuse throughout the random potential. As interferential correction to diffusive transport, we furthermore consider the phenomenon of coherent backscattering and analyze how this coherent effect is modified by interactions.

[1] T. Wellens and B. Grémaud, Phys. Rev. Lett. **100**, 033902 (2008).

DY 15.4 Wed 10:30 MA 004

Pressure fluctuations lead to assembly of smectic domains — •Marco Mazza[1] and Martin Schoen[1,2] — [1]Stranski-Laboratorium für Physikalische und Theoretische Chemie, Technische Universität Berlin, Straße des 17. Juni 135, 10623 Berlin, Germany — [2]Department of Chemical and Biomolecular Engineering, North Carolina State University, 911 Partners Way, Raleigh, NC 27695, U.S.A.

The interplay of geometry and directional interactions generates myriad different equilibrium phases in liquid crystal materials. However, comparatively little is known of their nonequilibrium behavior, especially in the case of nanoscopic confinement. Here, we perform nonequilibrium computer simulations of a system of prolate mesogens confined to a nanoscopic slit-pore. We apply a time-dependent surface anchoring at the walls. A steady state arises consisting of a smectic domain. We study the behavior of these smectic domains as temperature and frequency are varied.

We find that, although pressure and temperature are too low to form a smectic state, pressure fluctuations in the nonequilibrium steady state match the pressure fluctuations in equilibrium. Our calculations demonstrate in principle a novel method of manufacturing materials with a high degree of molecular order.

DY 15.5 Wed 10:45 MA 004

How to capture self-propelled particles — •Andreas Kaiser, Henricus H. Wensink, and Hartmut Löwen — Heinrich-Heine-Universität Düsseldorf

For many applications, it is important to catch collections of autonomously navigating microbes and man-made microswimmers in a controlled way. Here we design an efficient trap to capture rod-like elf-propelled particles collectively. By computer simulations in two dimensions, a V-shape is found to be the optimal boundary for a trapping device. The efficiency of catching can be largely tuned by the opening angle α of the trap. For increasing α, there is a sequence of three emergent states corresponding to partial, complete, and no trapping.

DY 15.6 Wed 11:00 MA 004

Experimentally realizable control functions: optimal control with arbitrary basis functions — •Selina Rohrer, Joachim Ankerhold, and Jürgen Stockburger — Institut für Theoretische Physik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm, Germany

Optimal control theory aims at driving a dynamical system towards a final state that minimizes a figure of merit and at finding the required time-dependent controls. Using the Moore-Penrose Pseudoinverse [1] we are able to find optimal control functions, not in the whole control space, but in a subspace, which is spanned by arbitrary, not necessarily orthogonal basis functions. This optimization technique allows us to take into account limitations of experimental set-ups, such as, eg., a finite rise time of the control pulses. To illustrate this optimization technique with different sets of basis functions, we study a harmonic oscillator as model system, which is coupled to a thermal environment. For all presented sets of basis functions, we are able to cool the system below the temperature of the coupled bath.

[1] R. Penrose, A generalized inverse for matrices. Proceedings of the Cambridge Philosophical Society 51, S. 406-413, 1955

15 min. break

DY 15.7 Wed 11:30 MA 004

Quantum cold ion heat engine at maximal efficiency — •Obinna Abah[1], Sebastian Deffner[2], Georg Jakob[3], Johannes Rossnagel[3], Kilian Singer[3], Ferdinard Schmidt-Kaler[3], and Eric Lutz[1,4] — [1]Department of Physics, University of Augsburg, D-86135 Augsburg, Germany — [2]Department of Chemistry and Biochemistry, University of Maryland, College Park, MD 20742 USA — [3]Institut für Quantenphysik, Universität Mainz, D-55128 Mainz, Germany — [4]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, D-14195 Berlin-Dahlem, Germany

We propose an experimental realizable quantum Otto heat engine working with a single ion in a segmented linear Paul trap. We analyze the theoretical efficiency at maximum power for adiabatic and nonadiabatic processes, both in the limit of high and low temperatures. We moreover present results from numerical simulations with realistic parameters.

DY 15.8 Wed 11:45 MA 004

Counting statistics of an electronic Maxwell's demon — •Gernot Schaller, Clive Emary, Gerold Kiesslich, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Berlin

A single-electron transistor (SET) that is continuously monitored by a quantum point contact may function as Maxwell's demon when closed-loop feedback operations are applied as time-dependent modifications of the tunneling rates across its junctions. The device may induce a current across the SET even when no bias voltage or thermal gradient is applied. For sufficiently strong feedback, it is also possible to transport electrons against an existing voltage (or thermal) gradient. We compare the generated power for different feedback schemes with the heat arising from Landauers principle and find no violation of the second law.

G. Schaller *et al.*, Phys. Rev. B **84**, 085418 (2011).

DY 15.9 Wed 12:00 MA 004

Current fluctuation theorems under incomplete monitoring — •Thilo Krause, Gernot Schaller, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Berlin

We demonstrate the validity of the fluctuation theorem for a double quantum dot surrounded by four terminals within the Born-, Markov- and secular approximations beyond the Coulomb-blockade regime. The electronic tunneling to two fermionic contacts conserves the total number of electrons, and the internal tunneling is phonon-assisted by two bosonic baths. Adapted choice of thermodynamic parameters between the baths may drive a current against an existing electric or thermal gradient. We study the apparent violation of the fluctuation theorem when only some of the energy and matter currents are monitored.

T. Krause, G. Schaller, and T. Brandes, Phys. Rev. B **84**, 195113 (2011).

DY 15.10 Wed 12:15 MA 004

Thermodynamics of genuine non-equilibrium states under feedback control — •David Abreu and Udo Seifert — II. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart, Germany

The work extracted from a thermodynamic system can exceed the free energy difference between final and initial states if feedback control is implemented. For transitions between equilibrium states, Sagawa and Ueda showed that the Jarzynski equality - and therefore the second law of thermodynamics - can be generalized to take into account the information obtained through measurements [1].

In the case of transitions between genuine non-equilibrium states that even at fixed external control parameter exhibit dissipation, we extend the Hatano-Sasa equality to processes with feedback control [2]. The resulting bound on the maximal extractable work is substantially sharper than what would follow from applying the Sagawa-Ueda equality to transitions involving such states. For repeated measurements at short enough intervals, the power thus extracted can even exceed the average cost of driving as demonstrated explicitly with a simple, analytically solvable example.

[1] T. Sagawa and M. Ueda. Phys. Rev. Lett. 104, 090602 (2010).
[2] D. Abreu and U. Seifert. arXiv: 1109.5892 (2011).

DY 15.11 Wed 12:30 MA 004

Information free energy for nonequilibrium states — Sebastian Deffner[1] and •Eric Lutz[2] — [1]Department of Chemistry and Biochemistry, University of Maryland, College Park, MD 20742 — [2]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin

We introduce an information free energy for thermodynamic systems driven by external time-dependent parameters. We show that the latter is a nonequilibrium state function and that it is a natural generalization of the usual equilibrium free energy. We discuss its importance for the maximum work theorem, the Jarzynski relation in the presence of feedback, and the relaxation to nonequilibrium steady states.

DY 15.12 Wed 12:45 MA 004

The thermodynamic cost of measurements — •Léo Granger and Holger Kantz — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

The measurement of thermal fluctuations provides information about the microscopic state of a thermodynamic system and can be used in order to extract work from a single heat bath in a suitable cyclic process. We present a minimal framework for the modeling of a measurement device and we propose a protocol for the measurement of thermal fluctuations. In this framework, the measurement of thermal fluctuations naturally leads to the dissipation of work. We illustrate this framework on a simple two states system inspired by the Szilard's information engine.

Topical Talk DY 15.13 Wed 13:00 MA 004

Impact of interaction effects on hopping transport in driven systems — •Mario Einax — Fachbereich Physik, Universität Osnabrück, Barbarastraße 7, 49076 Osnabrück, Germany

Particle transport in low-dimensional biological, chemical and physical systems is of vital importance for many applications and has hence attracted much attention in recent years. Prominent examples are Brownian motors and ratchets, photovoltaic cells, and electron transport in the incoherent limit in molecular wires. A one-dimensional hopping motion is also the decisive transport mechanism in ion conduction through membrane channels and in unidirectional motion of motor proteins along filaments. Driven lattice gases offer a promising approach for studying the role of interaction effects between transported particles in such systems. In this talk I will review how by using the time-dependent density functional theory (TDFT) for lattice systems a systematic method is provided that allows one to treat the kinetics of driven lattice gases with interactions. To demonstrate its effectiveness, I will consider the motion of interacting particles through an open channel under peristaltic driving [1] and a totally asymmetric site exclusion process (TASEP) with nearest-neighbor interactions [2,3].

[1] M. Einax, G. C. Solomon, W. Dieterich, and A. Nitzan, J. Chem. Phys. **133**, 054102 (2010).

[2] M. Dierl, P. Maass, and M. Einax, Europhys. Lett. **93**, 50003 (2011).

[3] M. Dierl, P. Maass, and M. Einax, Phys. Rev. Lett., in Press (2012).

DY 16: Fluid dynamics and turbulence II

Time: Wednesday 10:00–12:00 Location: MA 144

Topical Talk DY 16.1 Wed 10:00 MA 144

Pepsi®–or ☺ interfacial instabilities between magnetic/nonmagnetic liquids — •Reinhard Richter — Experimentalphysik 5, Universität Bayreuth

Turn a can upside down and lift the pull-tab! The heavier liquid will start to leave the vessel through the small orifice, whereas air tries to enter it from below. This unstable condition is known as Rayleigh-Taylor instability. For magnetic beverages it may become *stable* by applying a rotating magnetic field, oriented parallel to the flat interface [1]. We present a first experimental confirmation [2] of this prediction and measure the shape of the interface for different magnetic fields utilizing radioscopy [3].

On the contrary, a magnetic liquid layer will become *unstable* if the field is oriented normally to the interface, and a critical field strength is surpassed. The resulting Rosensweig instability is measured in a highly viscous ferrofluid via a sequence of magnetic pulses. This allows us to catch the phase space dynamics, and to reconstruct the underlying fully nonlinear equation of motion of the pattern amplitude [4]. When exploring the control parameter-phase space, localized states are uncovered next to the unstable branch of the bifurcation diagram.

[1] D. Rannacher and A. Engel, Phys. Rev. E **75**, 016311 (2007). [2] A. Poehlmann, Diplomarbeit, Universität Bayreuth (2011). [3] R. Richter and J. Bläsing, Rev. Sci. Instrum. **72**, 1729 (2001). [4] C. Gollwitzer, I. Rehberg, and R. Richter, New J. Phys. **12**, 093037 (2010).

DY 16.2 Wed 10:30 MA 144

Identifying Heat Transport Processes in Turbulent Rayleigh-Bénard Convection via a PDF Equation Approach — •Johannes Lülff[1], Richard J.A.M. Stevens[2], Michael Wilczek[1], Rudolf Friedrich[1], and Detlef Lohse[2] — [1]Institute for Theoretical Physics, University of Münster, Wilhelm-Klemm-Straße 9, 48149 Münster, Germany — [2]Department of Science and Technology and J. M. Burgers Center for Fluid Dynamics, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

Rayleigh-Bénard convection, i.e. the convection of a fluid enclosed between two plates that is driven by a temperature gradient, is the idealized setup of a phenomenon ubiquitous in nature and technical applications. Of special interest for this system are the statistics of turbulent temperature fluctuations, which we are investigating for a fluid enclosed in a cylindrical vessel.

To this end, we derive an exact evolution equation for the probability density function (PDF) of temperature from first principles. Appearing unclosed terms are expressed as conditional averages of velocities and heat diffusion, which are estimated from direct numerical simulations.

Our theoretical framework allows to connect these statistical quantities to the dynamics of Rayleigh-Bénard convection, giving deeper insights into the temperature statistics and transport mechanisms in different regions of the fluid volume, i.e. in the boundary layers, the bulk and the sidewall regions.

DY 16.3 Wed 10:45 MA 144

Rotor model for the inverse cascade of two-dimensional turbulence — •Benjamin Motz and Rudolf Friedrich — Institute for Theoretical Physics, University of Münster, Wilhelm-Klemm-Str. 9, D-48149 Münster

We investigate dynamical aspects of the inverse cascade, a central phenomenon of two-dimensional turbulence. Kirchhoff's point vortex model for fluid motion is extended by gluing together two equally-signed point vortices to one rotor. This allows to include the effects of shear, still permitting to analyze the flow in terms of a dynamical system. Our theoretical studies are supported by numerical results of the rotor model. The results are compared to direct numerical simulations of homogeneous isotropic turbulence.

DY 16.4 Wed 11:00 MA 144

Gaussian vortex approximation to the instanton equations of two-dimensional turbulence — •Kolja Kleineberg and Rudolf Friedrich — Institute for Theoretical Physics, University of Münster, Germany

We investigate two dimensional turbulence within the instanton formalism. The instanton formalism determines the most probable field in a stochastic classical field theory starting from the Martin-Siggia-Rose path integral. To this end, we derive a history dependent equation for the Langrangian velocity and vorticity field using a point vortex approach. A variational ansatz using elliptical vortices leads to a set of evolution equations for the positions and the shapes of the vortices. We discuss the relationship of this dynamical system to the inverse cascade process of two-dimensional turbulence.

DY 16.5 Wed 11:15 MA 144

Modeling of bacterial turbulence — •Sebastian Heidenreich[1], Henricus H. Wensink[2], Knut Drescher[3], and Jörn Dunkel[3] — [1]Physikalisch Technische Bundesanstalt Berlin, Germany — [2]Heinrich-Heine-Universität Düseldorf, Germany — [3]University of Cambridge, UK

From large scale atmospheric plasma instabilities to small scale bacterial turbulence, irregular flow motion appears in very different fluid systems. The investigation of system independent universal properties give a deep insight into the character of turbulence. In particular, the study of bacterial turbulence may lead to a better understanding of both the collective behavior of active soft matter and universal properties of turbulence. In the presentation, for the description of self-sustained bacterial turbulence continuum equations are introduced and numerical solutions are discussed. For the characterization of turbulence statistical quantities as structure functions, energy scalings and velocity distributions are derived. The results are in a good agreement with experimental data of bacillus subtilis and self-propelled hard rods molecular dynamics simulations.

DY 16.6 Wed 11:30 MA 144

Experimentelle Untersuchung des turbulenten Strömungsnachlaufs eines fraktalen Gitters mittels PIV — •André Fuchs, Christian Strüwing, Hannes Hochstein, Joachim Peinke und Gerd Gülker — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg

Die genaue Beschreibung von Turbulenzen ist aufgrund des komplexen und chaotischen Strömungsverhaltens eines der großen ungelösten Probleme der Wissenschaft. Aus diesem Grund besitzt die experimentelle Untersuchung in dieser Forschungsrichtung eine hohe Relevanz. Zur Erzeugung einer turbulenten Luftströmung werden in realen Strömungsanalysen im Windkanal derzeit vermehrt sogenannte fraktale Gitter eingesetzt. Forschungsergebnisse, die aus Analysen mittels der Hitzdrahtanemometrie resultieren, zeigen dabei, dass sich der Strömungsnachlauf und die sich ausbildenden Strukturen hinter einem fraktalen Gitter, deutlich von dem Nachlauf hinter einem klassischen Gitter unterscheiden. So steigt im Fall eines fraktalen Gitters zunächst die Turbulenzintensität im Nachlauf stromabwärts weiter an und besitzt ein Maximum in einer gitterspezifischen Entfernung. Im Gegensatz dazu nimmt die Turbulenzintensität hinter einem klassischen Gitter kontinuierlich ab. In der experimentellen Untersuchung dieser Strömungsprozesse mittels des Particle Image Velocimetry Messverfahren (PIV) konnte dieses Verhalten bestätigt werden. Im Vortrag werden die Ergebnisse dieser Analyse vorgestellt und mit numerischen CFD Simulationen (Computational Fluid Dynamics) des turbulenten Nachlaufs eines fraktalen Gitters verglichen.

DY 16.7 Wed 11:45 MA 144

Investigations of cavity noise generation on a cylinder — •Tim Homeyer[1], Nils Kirrkamm[1], Christopher Haut[3], Manfred Schultz-von Glahn[2], Gerrit Kampers[1], Joachim Peinke[1], Volker Mellert[3], and Gerd Gülker[1] — [1]ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg — [2]ITAP - Institut für Technische und Angewandte Physik GmbH, Oldenburg — [3]Acoustics, Institute of Physics, University of Oldenburg

Cavity noise generation was under investigation in various studies and is today of particular interest for e.g. the aeronautical and automotive industry. The boundary layer plays a major role in the characterization of the flow in and around the cavity. In this work a small overflowed cavity on a cylinder at flow velocity ramps up to 45 m/s is under investigation. It turns out, that the standard cavity noise theory is not applicable for this particular setup.
Acoustical, PIV, smoke and Hot-Wire measurements were performed. A sudden transition of the circulating flow (drag crisis) at the expected Reynolds number lead to vorticies flow over the cavity. The onset of the acoustic radiation of the cavity is simultaneous with this transition and shows a strong hysteresis. CFD simulations with OpenFoam are performed to investigate the three-dimensional flow instabilities. All results indicate that the Kelvin-Helmholtz instabilities are the reason for the acoustic noise generated by the cavity.
In this presentation measurements and simulations will be presented and discussed.

DY 17: Networks I (with SOE)

Time: Wednesday 9:30–10:15 Location: H 0110

Invited Talk DY 17.1 Wed 9:30 H 0110

Adaptive Networks of Opinion Formation in Humans and Animals — •Thilo Gross — University of Bristol, Department of Engineering Mathematics, Merchant Venturers School of Engineering, Bristol, UK

A central challenge in socio-physics is understanding how groups of self-interested agents make collective decisions. For humans many insights in the underlying opinion formation process have been gained from network models, which represent agents as nodes and social contacts as links. Over the past decade these models have been expanded to include the feedback of the opinions held by agents on the structure of the network. While a verification of these adaptive models in humans is still difficult, evidence is now starting to appear in opinion formation experiments with animals, where the choice that is being made concerns the direction of movement. In this talk I show how analytical insights can be gained from adaptive networks models and how predictions from these models can be verified in experiments with swarming animals. The results of this work point to a similarity between swarming and human opinion formation and reveal insights in the dynamics of the opinion formation process. In particular I show that in a population that is under control of a strongly opinionated minority a democratic consensus can be restored by the addition of uninformed individuals.

DY 18: Networks II (with SOE)

Time: Wednesday 10:15–12:45 Location: H 0110

DY 18.1 Wed 10:15 H 0110

Diffusion on random networks with spatial constraints — •Thorsten Emmerich[1], Shlomo Havlin[2], and Armin Bunde[3] — [1]Institut für Theorethische Physik 3, Justus Liebig Universität Giessen, Giessen, Germany — [2]Minerva Center and Department of Physiks, Bar Ilan University, Ramat Gan, Israel — [3]Institut für Theorethische Physik 3, Justus Liebig Universität Giessen, Giessen, Germany

We consider random networks with spatial constraints. The networks are embedded in a linear chain or in a square lattice with embedding dimension $d_e = 1$ and 2, respectively. Each node has a fixed number of links. The length of the links are chosen with probability $p(r) \sim r^{-\delta}$, where r is the Euclidean distance between them. We show how the dimension of those networks can be determined and that it plays a basic role in determining the dynamical properties of the networks. The physical features are determined by δ: For $\delta < d_e$, the spatial constraints are irrelevant, while for $\delta > 2d_e$ the network behaves as a regular lattice. In between, for $d_e \leq \delta \leq 2d_e$ the network shows intermediate behavior and its dimension increases monotonically with decreasing δ.
We show that the dimension obtained from evaluating the structure of the networks appears also in the probability of return to the origin of a diffusing particle as well as in the survival properties of diffusing particles in the chemical reactions $A + A \rightarrow C$ und $A + B \rightarrow C$.

DY 18.2 Wed 10:30 H 0110

Topological properties of networks with spatial constraints — •Stefano Mattiello[1], Shlomo Havlin[2], and Armin Bunde[1] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität Giessen, Giessen, Germany — [2]Minerva Center and Department of Physics, Bar-Ilan University, Ramat-Gan, Israel

We investigate the effects of spatial constraints on the topological properties of networks embedded in one or two dimensional space. The nodes are embedded in a linear chain or in a square lattice with embedding dimension $d_e = 1$ and $d_e = 2$, respectively. The length of the links are chosen with probability $p(r) \sim r^{-\delta}$, where r is the Euclidean distance between them. We consider Erdös -Rényi networks, where the distribution of the degrees of the nodes is Poissonian, as well as scale-free networks where the degree distribution follows a power law

$P(k) \sim k^{-\gamma}$, with γ typically between two and three.

We study the mean topological distance l and the clustering coefficient C of both kind of networks. We focus on the dependence of these properties on the size of the system N and the exponent δ, in particular in the region $d_e \leq \delta \leq 2d_e$, where we expect an anomalous behavior.

DY 18.3 Wed 10:45 H 0110

Vaccine allocation in metapopulations — •Vitaly Belik — Massachusetts Institute of Technology, Cambridge, MA, USA — Max-Planck-Institut für Dynamik und Selbstorganization, Göttingen

Preparing for the 2009 H1N1 influenza pandemic, goverments of many countries acquired large stocks of vaccine or antivirals against this influenza strain. However due to low uptake of the vaccine in the population the governments needed to destroy the vaccine thus loosing many millions of dollars. This motivates the question addressed in this study - how to distribute the vaccine in the economically optimal way among different geographical regions. We propose an approximative method allowing with relatively little computational efforts to determine the optimal vaccination levels in real world systems for influenza-like diseases.

DY 18.4 Wed 11:00 H 0110

Interplay between epidemics and network topology in a growing population — •Güven Demirel[1] and Thilo Gross[2] — [1]Max Plax Institute for the Physics of Complex Systems, Dresden, Germany — [2]Merchant Venturers School of Engineering, University of Bristol, Bristol, UK

The structure of social contact networks strongly influences the dynamics of epidemic diseases. In particular the scale-free structure of real-world social networks allegedly allows unlikely diseases with low infection rates to spread and become endemic. However, in particular for potentially fatal diseases also the impact of the disease on the social structure should not be neglected. In this study, we consider the growth of a network by preferential attachment from which nodes are simultaneously removed due to an SIR epidemic. By comparison to network simulations we show that the interplay between topological evolution and epidemic dynamics can be captured by an analytical approximation. This reveals that increased infectivity increases the prevalence of the disease but also leads to the reemergence of an epidemic threshold by causing a transition from scale-free to exponential topology.

DY 18.5 Wed 11:15 H 0110

The vaccination dilemma with imperfect effectiveness — •Bin Wu[1,2], Feng Fu[1], and Long Wang[1] — [1]Center for Systems and Control, College of Engineering, Peking University, Beijing 100871, China — [2]Max-Planck-Institute for Evolutionary Biology, Plön 24306, Germany

Achieving widespread population immunity by voluntary vaccination poses a major challenge for public health administration [1]. The situation is complicated even more by imperfect vaccines. How the vaccine efficacy affects individuals' vaccination behavior has yet to be fully answered. To address this issue, we combine a game theoretical model of vaccination behavior with an epidemiological process. Our analysis shows that, in a population of self-interested individuals, the vaccine uptake level increases rapidly as the effectiveness of vaccination increases. Moreover, when the basic reproductive number exceeds a certain threshold, all individuals opt for vaccination for an intermediate region of vaccine efficacy. We further show that increasing effectiveness of vaccination always increases the number of effectively vaccinated individuals and therefore attenuates the epidemic strain. The results suggest that although increases in vaccination effectiveness lead to increased uptake level, it may drop due to free-riding effects. Nonethelss, the impact of the epidemic is mitigated by more effective vaccines [2].

[1] Rino Rappuoli, Science 316: 1287 (2007)
[2] Bin Wu, Feng Fu and Long Wang, PLoS ONE 6(6): e20577 (2011)

15 min. break

DY 18.6 Wed 11:45 H 0110

Cascading Failures on the Banking Network — •Maximilian Thess[1,2], Eckehard Schöll[2], and Sitabhra Sinha[1] — [1]Institute of Mathematical Sciences Chennai, India — [2]Institut für Theoretische Physik, Technische Universität Berlin, Germany

Following the recent financial crisis complex networks have been applied increasingly to study properties of the financial system. The interplay between topology and dynamics of networks is of current interest in systems ranging from physics and biology to the social sciences and economics. Dynamical and topological properties of the financial system are of crucial importance to its stability and an increased understanding can inform for example better regulatory policies.

In our contribution we study a simple model of cascading bank failures on the US interbank lending network. We characterize the network using measures from complex network theory and illustrate local and global stability. Through numerical simulations we study the impact of single-bank defaults on global system stability. To identify superspreader-banks based on their topological features we compare several ways of measuring their importance .

DY 18.7 Wed 12:00 H 0110

The informativeness of local constraints in the structure of the global trade network — •Tiziano Squartini[1], Giorgio Fagiolo[2], and Diego Garlaschelli[1] — [1]Lorentz Institute for Theoretical Physics, University of Leiden, Niels Bohrweg 2, NL-2333 CA Leiden, The Netherlands — [2]LEM, Sant'Anna School of Advanced Studies, Pisa, ITALY

The network of international trade relationships, or World Trade Web (WTW), has received renewed multidisciplinary interest due to recent advances in network theory. However, it is still unclear whether the network approach conveys additional, nontrivial information with respect to traditional international-economics analyses that describe world trade only in terms of local country-specific properties. In this work we use a recent randomization method to assess in detail the role that local structural properties have in shaping higher-order patterns of the WTW in all its possible representations (binary/weighted, directed/undirected, aggregated/disaggregated) and across several years. We find that all higher-order properties observed in the binary description can be completely traced back to the degree sequence, which is therefore maximally informative. This implies that the degree sequence, which is currently neglected by economic models, should instead become among the focuses of theories. By contrast, the weighted patterns of the WTW cannot be completely explained by local properties, which are therefore of limited informativeness. Indirect weighted trade interactions are not simply combinations of direct ones, and can only be successfully captured by the network description of trade.

DY 18.8 Wed 12:15 H 0110

Networks of animal trade: from temporal paths to epidemic centrality — •Mario Konschake[1,3], Hartmut Lentz[1,2], Thomas Selhorst[1], Igor M. Sokolov[2], and Philipp Hövel[3] — [1]Friedrich-Loeffler-Institut, Wusterhausen — [2]Humboldt-Universität, Berlin — [3]Technische Universität, Berlin

Centrality of nodes is a major concept in network epidemiology which has been extensively studied. For temporal networks, however, a theoretical understanding is still in its infancy. In our case, a time-resolved topology arises from a series of static snapshots of the network taken at discrete time steps. The available animal-trade data has a temporal resolution of one day and includes 90.000 nodes.

We report on epidemiological relevant centrality measures based on the spread of an SIR-type disease. We analyse the robustness of the proposed measures under varying time of primary infection and under different infectious periods. We find the ranking of the nodes according to the measures sufficiently stable for different infectious periods, to be utilizable in the practical contexts of disease prevention and control. We thereby conclude that, for the analysed network, nodes with high epidemiological centrality can be identified independently of a specific disease.

We also find a threshold in the final size of the epidemic, so that diseases with an infectious period shorter than the intrinsic time constant of the network cannot propagate.

DY 18.9 Wed 12:30 H 0110

A comparison of probabilistic distribution for fitting the degree distribution of real-world social networks — •Faustino Prieto and Jose Maria Sarabia — University of Cantabria, Santander, Spain

In this paper, the degree distribution of social and information networks is analyzed. Several functional forms have been proposed in the network science literature, including the classical power law and many others. Now, six different probabilistic models are fitted in the entire range by maximum likelihood. The used models are Lognormal, Gamma, Weibull, power law and two special cases of the Pareto Positive Stable (PPS) distribution. The models are compared using the Akaike information criterion (AIC) and the Kolmorov-Smirnov (KS) statistic. A two-parameter PPS distribution is found to be the better choice in the whole range, to several social and information network datasets. Finally, the PPS model is validated graphically by using log-log rank-size plots and double log-log plots.

DY 19: Nonlinear Dynamics of the Heart: Contributed talks to focus session

Time: Wednesday 15:00–16:45 Location: MA 001

DY 19.1 Wed 15:00 MA 001

From Vascular Structures to Cardiac Activation Dynamics — •Daniel Hornung[1,2], Philip Bittihn[1,2], Amgad Squires[1], Flavio Fenton[1,3], and Stefan Luther[1,2,3] — [1]Max-Panck-Institut für Dynamik und Selbstorganisation Göttingen — [2]Institut für Nichtlineare Dynamik, Georg-August-Universität Göttingen — [3]Department of Biomedical Sciences, Cornell University

Under externally applied electric fields, heterogeneities in cardiac muscle tissue may serve as sources of cellular activation and thus emit waves of muscular excitation. This effect is most promising on the search for new, more gentle, low energy defibrillation techniques, and quantitative methods for assessing these heterogeneities and their effects on cardiac (de)fibrillation are of the greatest importance.

We show a method to convert the measured sizes of cardiac coronary blood vessels – one kind of the mentioned heterogeneities – into a prediction of the heart activation under external electric fields.

By using micro X-ray computed tomography images of heart tissue, we are able to automatically reconstruct the structure of the coronary arterial vascular tree. The blood vessel diameter distribution in this tree follows a power law, which can then be transformed, using know relations between size and excitability, into a prediction of the time required to activate the whole tissue by an electric stimulus of a given strength. The relation between activation time and electric field strength also follows a power law, where the two respective exponents can be easily converted into one another.

DY 19.2 Wed 15:15 MA 001

On the possible generation of atrial fibrillation by mutually interacting excitation sources — •Claudia Lenk[1], Gunnar Seemann[2], Mario Einax[3], and Philipp Maass[3] — [1]Institut für Chemie, Technische Universität Ilmenau, Germany — [2]Institut für Biomedizinische Technik, Karlsruhe Institute of Technology, Germany — [3]Fachbereich Physik, Universität Osnabrück, Germany

Atrial fibrillation (AF) is the most common arrhythmia of the heart which, amongst others, strongly increases the risk of stroke. As a possible new generating mechanism of AF we study the interaction of two pacemakers located in separate regions connected by a small bridge. In our setup the sinus node is considered as the primary pacemaker, while the secondary pacemaker is representing self-excitatory sources as ectopic foci and microreentrant circuits, which are often observed in the left atrium of AF patients. Our calculations are based on the model of Bueno-Orovio *et al.* (BO model) with a specific adaption of parameters to the electrophysiology of the atria. The results are compared to solutions of the more generic FitzHugh-Nagumo (FHN) equations in order to get insight how far mechanisms are specific to electrophysiological peculiarities of the atria. Three different types of irregular excitation patterns with similarities to fibrillatory states can be identified in the FHN model for certain frequency ratios of the two pacemakers, but only one of them is present in the BO model. The reason for the higher robustness of the regular states in the BO model is discussed as well as effects of electrophysiological remodelling on the dynamical excitation patterns.

DY 19.3 Wed 15:30 MA 001

Cardiac contraction and mechano-electric feedback promotes discordant alternans — Enric Álvarez-Lacalle[1], Markus Bär[2], Blas Echebarria[1], and •Markus Radszuweit[2] — [1]Dept. Física Aplicada, Universitat Politècnica de Catalunya, 44-50 Av. Dr. Maranón, 08028 Barcelona, Spain — [2]Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, 10587 Berlin, Germany

By means of numerical simulations of the Fenton-Karma model with electromechanical coupling we investigate the effect of contraction on cardiac alternans. The study is confined to action potential propagation along a quasi-one-dimensional cable where the mechanoelectrical feedback on the membrane voltage results from stretch-activated currents. The electromechanical coupling is approximated by a global coupling term following Alvarez-Lacalle and Echebarria, Phys. Rev. E 79, 031921 (2009). Discordant alternans is often a precursor for life-threatening arrhythmias like ventricular fibrillation and is often caused by a steep slope of conduction velocity (CV) restitution curve. Here, we show that contraction switches the dynamics from concordant to discordant alternans even when the CV restitution curve is practically flat at the onset of alternans. This result demonstrates the need to include the mechanics of the tissue in models of electrical propagation.

DY 19.4 Wed 15:45 MA 001

Dynamical impact of structural heterogeneities in electrically-stimulated cardiac tissue — •Philip Bittihn[1], Marcel Hörning[2], and Stefan Luther[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Department of Physics, Graduate School of Science, Kyoto University, Kyoto, Japan

Acute heart rhythm disorders such as fibrillation that underly sudden cardiac death are one of the leading causes of death in the industrialized world. When fibrillation arises, normal rhythm is usually restored using electrical shocks. In the last decade, both experiments and computationally intensive numerical simulations have been aimed at modeling the underlying mechanisms and at the improvement of these control strategies. Here, we theoretically target a basic feature of cardiac tissue that leads to its heterogeneous response to electric fields: its complex geometry. We examine mathematically how the shape of both internal and external tissue boundaries modifies the changes in membrane potential induced by electric fields. The results are confirmed both in cardiomyocyte cell culture experiments and in numerical simulations. Furthermore, we examine numerically how stimulation protocol parameters influence the ability of heterogeneities to act as wave sources. These investigations open the way to a profound theoretical understanding of electric-field stimulation effects in cardiac tissue.

DY 19.5 Wed 16:00 MA 001

Negative tension of scroll wave filaments in cardiac tissue — •Sergio Alonso[1], Markus Bär[1], and Alexander V. Panfilov[2] — [1]Physikalisch-Technische Bundesanstalt, Abbestrasse 2-12, 10587 Berlin, Germany — [2]Department of Physics and Astronomy, Gent University, Krijgslaan 281, S9 9000 Gent, Belgium

Scroll waves are vortices that occur in three-dimensional excitable media. Scroll waves have been observed in a variety of systems including cardiac tissue, where they are associated with cardiac arrhythmias. The disorganization of scroll waves into chaotic behavior is thought to be the mechanism of ventricular fibrillation, whose lethality is widely known. One possible mechanism of scroll wave instability is negative filament tension. It was discovered in 1987 in a simple two variables model of an excitable medium. Since that time negative filament tension of scroll waves and the resulting complex, often turbulent dynamics was studied in many generic models of excitable media and physiologically realistic models of cardiac tissue. Here we discuss the relation of negative filament tension and tissue excitability and the effects of discreteness in the tissue on the generation of the negative filament tension. We discuss the application of the negative tension mechanism to computational cardiology, where it is regarded as a fundamental mechanism that explains differences in the onset of arrhythmias in thin two-dimensional and thick three-dimensional tissue.

DY 19.6 Wed 16:15 MA 001

Characterization of complex spatio-temporal dynamics in cardiac tissue and its potential use in tomographic imaging techniques — •Jan Christoph[2] and Stefan Luther[1,2,3] — [1]Heart Research Center, Göttingen — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen — [3]Dept. of Biomedical Sciences, Cornell University, USA

Complex electromechanical spatio-temporal dynamics are the underlying mechanisms beneath cardiac arrhythmia, including vortex-like rotating scroll waves. Fluorescence imaging (optical mapping) uses voltage sensitive dyes to provide high-resolution data of cardiac excitation waves; however, this technique is limited to the surface of the heart. For a better understanding of the underlying three-dimensional dynamics inside the tissue, new imaging techniques capable of resolving the electromechanical dynamics deep inside the heart are needed. We hypothesize that characteristic properties of three-dimensional spatio-temporal dynamics in cardiac tissue may be obtained from high-resolution strain measurements during the active contraction of the cardiac muscle and that these patterns reveal differences in physiological and pathological function of the heart. We compare strain patterns obtained in simulations of an elastic excitable medium with typical patterns occurring in experiments and discuss technical challenges and limitations that are involved with the experimental investigations.

DY 19.7 Wed 16:30 MA 001

Percolation-induced reexcitation in a discrete model for heterogeneous excitable cardiac tissue — Sergio Alonso and •Markus Bär — Physikalisch-Technische Bundesanstalt, Abbestrasse 2-12, 10587 Berlin, Germany

Arrhythmias in cardiac tissue are related with electrical wave propagation in the heart. Cardiac tissue is formed by a discrete network, which is often heterogeneous. It is shown by extensive simulation in a discrete model that a wave crossing a highly heterogeneous region of cardiac tissue may breakup and produce irregular patterns, when the fraction of heterogeneities is close to the percolation threshold of the cell network. The results are generic for heterogeneous excitable media and do not depend on the exact structure of the cells in cardiac tissue.

DY 20: Networks III

Time: Wednesday 15:00–16:45 Location: MA 004

DY 20.1 Wed 15:00 MA 004

Efficient transport and symmetries in models of Light Harvesting Systems — Tobias Zech[1], •Roberto Mulet[1,2], Torsten Scholak[1], Thomas Wellens[1], and Andreas Buchleitner[1] — [1]Quantum optics and statistics, Institute of Physics Albert Ludwigs University of Freiburg Hermann-Herder-Str. 3 D-79104 Freiburg — [2]Group of Complex Systems, Department of Theoretical Physics. Physics Faculty, University of Havana. La Habana, Cuba

Recent experimental results suggest the existence of quantum coherence and efficient transport in Light Harvesting Systems. Particularly motivated by results on the FMO complex we study exciton transport in random tri-dimensional lattices of seven sites with long range dipolar interactions. We show that some of these networks are consistent with efficient transport.

Moreover, we present evidence that the statistically relevant Hamiltonians associated with the efficient transport are centro-symmetric. We compare our results with numerical tests on realistic Hamiltonians for Light Harvesting systems and present a finite size scaling analysis of the model. Some implications of our results for the comprehension of the role of symmetry in Biology and for Quantum Communications are outlined.

DY 20.2 Wed 15:15 MA 004

Traveling fronts and stationary patterns in bistable reaction-diffusion systems on networks — •Nikos Kouvaris[1], Hiroshi Kori[2], and Alexander Mikhailov[1] — [1]Department of Physical Chemistry, Fritz Haber Institute of the Max Planck Society, Faradayweg 4-6, D-14195 Berlin, Germany — [2]Division of Advanced Sciences, Ochadai Academic Production, Ochanomizu University, Tokyo 112-8610, Japan

We focus on activation fronts in bistable one-component systems on large complex networks. Fronts can trigger a transition from the one stable state to the other which spreads in the entire network. However, depending on the connectivity pattern of the network and the strength of diffusive coupling, the fronts can be pinned forming stationary localized patterns or can be retracted into their sources. Particularly, a front can be spread through nodes with low degrees, can be pinned at nodes with higher degrees, or can be retracted from nodes with even higher degrees. Similar behavior is observed for various values of coupling. This reach dynamical behavior can be described in terms of a mean field theory, while for the specific class of complete k-ary tree networks, saddle-node bifurcations have been found that distinguish the different dynamical regimes of traveling fronts and stationary patterns. Theoretical predictions have been verified by numerical simulations in large k-ary trees, Erdös-Rényi and scale-free networks, showing a very good agreement.

DY 20.3 Wed 15:30 MA 004

Network evolution towards optimal dynamical performance — •Steffen Karalus and Markus Porto — Institut für Theoretische Physik, Universität zu Köln, Germany

The functionality of a large number of real world networks is associated with dynamical processes based on the network in the sense that the network structure defines the local interaction pattern between the individual elements of the system. A deeper understanding of the interplay between the network topology and the behavior of the dynamical process in such cases is, however, still missing. As the 'fitness' of these networks is primarily determined by their functionality, we presume that they are driven into 'fitter' structures by an evolutionary process with mutation acting on topology and selection acting on dynamical properties. We propose a simple optimization scheme in which the latter are determined by the eigenvalue spectrum of the associated time evolution operator. Exemplifying this approach with the graph Laplacian, the relevant operator for fundamental processes such as random walks on a network, we show that our algorithm is able to successfully evolve networks into states with a given eigenvalue spectrum and corresponding dynamical behavior.

DY 20.4 Wed 15:45 MA 004

High performance simulation and visualization of epidemics on complex networks — •Peter A Kolski[1], Martin Clauss[2], Thomas Selhorst[3], and Arkadi Pikovsky[1] — [1]University of Potsdam, Germany — [2]University of Leipzig, Germany — [3]Friedrich-Loeffler-Institut, Germany

Dynamical processes on complex networks are a growing field of interest. Performing simulations on large system of this kind demand a high computational power. To handle dynamics on networks the NetEvo C++ library can assign dynamical systems to edges and nodes. Furthermore it solves these ODEs via the ODEint library and can perform heuristic optimization. We introduce an extension to NetEvo using OpenCL on GPUs. With this approach we achieve an increase of computational performance up to a factor of 87, compared to an optimized C++ code on a modern CPU. Additionally we developed a framework to visualize intermediate results and to perform instantaneous visual analytics. The software will be applied in epidemiology, simulating disease spread on trade networks by solving the SIR model*s ODEs. The modification of parameter in real-time and the immediate access to simulation results leads to intuitive insights into the behavior of epidemics on large complex networks.

DY 20.5 Wed 16:00 MA 004

Information spread via on-line networks: from time series to co-evolving functional networks — •Jan W. Kantelhardt[1], Mirko Kämpf[1], Shlomo Havlin[2], and Lev Muchnik[3] — [1]Institut für Physik, Martin-Luther Universität Halle-Wittenberg, Halle/Saale, Germany — [2]Physics Department, Bar-Ilan University, Ramat Gan, Israel — [3]Leonard N. Stern School of Business, New York University, USA

Human interaction and information spread via on-line networks is becoming increasingly important for our contemporary technological society. Here, we characterize and compare three organizational and dynamical network structures associated with the online encyclopedia Wikipedia. We study (i) the network of the direct links between Wikipedia articles of various languages, (ii) the usage network as determined from cross-correlations between click-count time series of many pairs of articles, and (iii) the edit network as determined from coincident edit events. The major goal is to find correlations between components of these three networks that characterize the dynamics of information spread in the complex system. We find that even though the dynamics of article click and edit time series are characteristically different - download activity is characterised by strongly persistent fluctuations (scaling exponent $\alpha \approx 0.9$), while edit activity is only short-term correlated - there are indications of a co-evolution of the corresponding dynamic networks. The results help in understanding the complex process of collecting, processing, validating, and distributing information in self-organised social networks.

DY 20.6 Wed 16:15 MA 004

Complete Reconstruction of Correlation Networks — •Jan Nagler, Magdalena Kersting, Annette Witt, and Theo Geisel — MPI DS, Göttingen

Consider a network of N vertices, each associated with a wide-sense stationary stochastic process. To what extent is it possible to reconstruct the interrelationships of the whole network knowing only a limited number of correlation functions? Under what circumstances is the system over- or underdetermined? Compared with the usual time series analysis we present a different approach to these questions by means of the Wiener-Khintchine Theorem and unfold the basic structure underlying correlation networks. Except for networks with certain loop structures, we show that either N crosscorrelation functions, or $N-1$ crosscorrelation functions together with a single autocorrelation function determine the full network dynamics. We analytically derive explicit expressions for the missing correlation functions and study exemplarily the ubiquitous case of exponentially decaying correlation functions.

DY 20.7 Wed 16:30 MA 004

Formation of the frozen core in critical Boolean Networks — •Marco Möller and Barbara Drossel — Festkörperphysik, TU Darmstadt, Germany

We investigate numerically and analytically the formation of the frozen core in critical random Boolean networks with biased functions. We demonstrate that a previously used efficient algorithm for obtaining the frozen core, which starts from the nodes with constant functions, fails when the number of inputs per node exceeds 4. We present computer simulation data for the process of formation of the frozen core and its robustness, and we show that several important features of the data can be derived by using a mean-field calculation.

DY 21: Granular Matter/Contact Dynamics

Time: Wednesday 14:30–17:15 Location: MA 144

DY 21.1 Wed 14:30 MA 144

Coefficient of restitution for wet impacts — Frank Gollwitzer[1], Christof Kruelle[2], Ingo Rehberg[1], and •Kai Huang[1] — [1]Experimentalphysik V, Universitaet Bayreuth, 95440 Bayreuth, Germany — [2]Maschinenbau und Mechatronik, Hochschule Karlsruhe - Technik und Wirtschaft, D-76133 Karlsruhe, Germany

As the experience of playing football in the rain may tell, wetting could influence the coefficient of restitution (COR) dramatically. This is due to the extra energy dissipation from the wetting liquid, for instance viscous damping. To unveil the underlying mechanisms accounting for the influence, we study experimentally the COR by tracing free falling particles bouncing on a wet surface. The dependance of the COR on the impact velocity, various particle and liquid properties will be presented and discussed in terms of dimensionless numbers that characterize the interplay between inertia, viscous and surface forces.

DY 21.2 Wed 14:45 MA 144

Exploring the 'no man's land' inbetween a granular and a colloidal suspension — •Welm Pätzold[1,2], Christoph Gögelein[1], and Matthias Schröter[1] — [1]Max Planck Institute for Dynamics and Self-organisation, Göttingen — [2]Georg-August-Universität Göttingen

The packing fraction in a liquid-fluidized bed depends on the suspension's viscosity. A number of empirical theories predict relations between the packing fraction and the necessary fluid velocity to obtain said packing fraction. We used a fluidized bed to investigate the fluidization and sedimentation processes of monodisperse glass spheres in the lower limits of the granular regime (down to 20 microns in diameter). We'll present data on the packing fraction versus the flow rate and test the above mentioned models.

DY 21.3 Wed 15:00 MA 144

Electrostatic precursors to granular slip events — •N Nirmal Thyagu[1,2] and Troy Shinbrot[1] — [1]Rutgers University, Piscataway, NJ 08854, USA — [2]MPI-DS, Goettingen, Germany

For at least the past 40 years, reports have repeatedly appeared of atmospheric lightning and related effects preceding major earthquakes. Many of these reports are anecdotal and of uncertain reliability, while others appear to have been substantiated by more recent scientific electric field measurements. In this work, we describe laboratory experiments that appear to exhibit sporadic, but statistically significant, electrical precursors to granular slip events. The cause of this phenomenon is unclear: the materials used are neither piezoelectric nor triboluminescent. We speculate that the electrical signals may be related to other electrical phenomena known to be associated with material failures in other contexts, for example in crack formation and in tape peeling.

DY 21.4 Wed 15:15 MA 144

Granular Gases of Anisometric Particles: A Microgravity Experiment — •Kirsten Harth[1], Torsten Trittel[1], Ulrike Kornek[1], Stephan Höme[2], Ulrike Strachauer[1], Karl Will[3], and Ralf Stannarius[1] — [1]Institut für Experimentelle Physik, Otto-von-Guericke Universität Magdeburg — [2]Institut für Automatisierungstechnik, Otto-von-Guericke Universität Magdeburg — [3]Institut für Elektronik, Otto-von-Guericke Universität Magdeburg

Although granular materials are widespread in nature and technological processes, a comprehensive dynamic theory is lacking. Depending on the type and strength of excitation, granulates display different aggregate states similar to thermodynamic states of matter. Granular gases represent dilute ensembles of grains interacting through inelastic collisions. At present, there is a vast amount of analytical or numerical predictions of physical properties of such gases, but only few experiments.

We investigate a granular gas of rodlike particles in microgravity on a sounding rocket. Videos are recorded from two stereoscopic perspectives during flight. Individual rods are tracked in consecutive frames. We analyse classical statistical quantities such as the distribution of energy on different degrees of freedom, orientation, velocity and density distributions. Two different excitation strengths and the cooling of the granular gas after change of the excitation parameters are investigated.

DY 21.5 Wed 15:30 MA 144

A local view on dilatancy onset in sheared granular media — •Annika Döring[1], Jean-François Métayer[1], Mario Scheel[2], and Matthias Schröter[1] — [1]Max Planck Institute for Dynamics and Self-organization, Göttingen, Germany — [2]European Synchrotron Radiation Facility Beamline ID15, Grenoble, France

A recent study on slowly sheared granular media has shown a change in the behaviour of the yield shear stress as a function of packing fraction Φ [1]: for packing fractions below 0.595 the shear stress depends weakly on phi whereas above this value the dependence on Φ is much stronger. It was suggested that this change is the signature of dilatancy.

In order to verify this hypothesis we made tomographies of a slowly sheared granular bed at the ESRF synchrotron in Grenoble.

Using Voronoi tessellation and particle tracking we have been able to access the local variation of the packing fraction and the individual displacement of grains while the bed is sheared. We present these quantities as a function of the initial packing fraction (before the bed is sheared) and test how it is related to the transition shown in [1].

[1] J-F. Métayer, D. Suntrup, C. Radin, H. Swinney, and M. Schröter, EPL 93 (2011) 64003

DY 21.6 Wed 15:45 MA 144

A two-species continuum model of aeolian sand transport — •Marc Lämmel, Daniel Rings, and Klaus Kroy — Institut für Theoretische Physik, Leipzig, Germany

Wind-driven sand transport is the dominant process shaping the geomorphology of arid regions on Earth, Mars and elsewhere. It is responsible for the spontaneous creation of a whole hierarchy of self-organized dynamic structures from ripples over isolated dunes to devastating fields of shifting sands. Provided that the wind is strong enough, you can even experience this transport process—called saltation—just by taking a walk on the beach, where sand clouds pass by, and every single grain tickles your ankles.

Here, we present a mathematical description of aeolian sand transport based on the successful continuum saltation model introduced in Ref. [1]. We show that a systematically improved version of this model can be derived by considering two species of trajectories, low-energy reptating grains and high-energy saltating grains—similar to what has been proposed in Ref. [2]. The resulting predictions are in remarkable agreement with flux data from various wind tunnel measurements.

[1] Sauermann, G., Kroy, K., Herrmann, H.J., 2001. Continuum saltation model for sand dunes. Phys. Rev. E 64, 031305.

[2] Andreotti, B., 2004. A two-species model of aeolian sand transport. Journal of Fluid Mechanics 510, 4770.

DY 21.7 Wed 16:00 MA 144

Jamming and glassy dynamics in driven particulate systems — •Claus Heussinger — Institute for theoretical physics, University Göttingen

The jamming paradigm aims at providing a unified view for the elastic and rheological properties of materials as different as foams, emulsions, suspensions or granular media. Apart from the industrial relevance of these materials, there is also a fundamental theoretical interest in the (athermal) jamming transition: as a new paradigm for structural arrest its relation to the (thermal) glass transition, the characterization of common and distinguishing features, remain to be elucidated.

By comparing different computational models we will discuss the question of universality on the macroscopic level of rheological observables as well as on the microscopic level of single particle trajectories and collective particle motion. We will show how small changes in the particle nteractions may lead to large changes in the response of the system. The goal is to delineate genuine aspects of a universal jamming transition from system-specific properties that depend on microscopic details, the driving mechanism or the preparation protocol.

DY 21.8 Wed 16:15 MA 144

Sorting of sand grains inside migrating dunes — Christopher Groh[1], Ingo Rehberg[1], and •Christof A. Krülle[1,2] — [1]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth, Germany — [2]Maschinenbau und Mechatronik, Hochschule Karlsruhe - Technik und Wirtschaft, D-76133 Karlsruhe, Germany

In general, agitated granular matter is known to show de-mixing whenever particles differ in size, shape or density. For example, inside natural sand dunes grain sorting phenomena are well-known features for geomorphologists coined reverse grading, when larger particles are found on top of smaller ones. Already in 1993 Anderson & Bunas demonstrated the effect of size segregation in a migrating dune by modeling the trajectories of large and small particles with a stochastic cellular automaton. Larger, and therefore heavier, grains travel in small jumps of the order of a few grain diameters, while smaller particles are able to leap over the crest far down into the shadow zone. Consequently, smaller particles end up being buried by larger ones at the toe of a dune. In addition, Makse (2000) showed that this size segregation due to different hopping lengths in the wake of a dune competes with a so-called shape segregation during transport and rolling of particles with different roughness along the dune's surface. Here we report results of an experimental investigation where the particles inside a downscaled model dune differ not in size or shape but in density, revealing that also denser particles accumulate on top of lighter ones and will finally end up close to the crest of a migrating dune [1].

[1] C. Groh, I. Rehberg, C.A. Kruelle, PRE 84, 050301(R) (2011).

DY 21.9 Wed 16:30 MA 144

Jamming and Random Close Packing of Ellipsoids — •Fabian M. Schaller[1], Gary W. Delaney[2], Max Neudecker[3], Sebastian C. Kapfer[1], Klaus Mecke[1], Matthias Schröter[3], and Gerd E. Schröder-Turk[1] — [1]Institut für Theoretische Physik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany — [2]CSIRO Mathematics, Informatics and Statistics, Clayton South, VIC 3169, Australia — [3]Max-Planck-Institut für Dynamik und Selbstorganisation, Am Fassberg 17, 37077 Göttingen, Germany

Disordered packings of ellipsoidal particles are a generalization of disordered sphere packings that can shed light on geometric features of random close packings and structural transitions in granular matter. Here we report the structure of ellipsoid packings in terms of contact numbers and Voronoi cell shapes, for several aspect ratios. Discrete approximations of generalized Voronoi diagrams are extracted from a large number of tomographic data of ellipsoid configurations, obtained by vertical shaking. Additionally, we performed DEM simulations of random ellipsoid packings. Their shape is quantified by isotropy indices $\beta_\nu^{r,s}$ based on Minkowski tensors[1,2]. These structural data contribute to a geometric understanding why the maximal random packing fractions of ellipsoids exceed that of monodisperse spheres.

[1] G.E. Schröder-Turk *et al.*, Disordered spherical bead packs are anisotropic, Europhys. Lett. **90**, 34001 (2010)
[2] G.E. Schröder-Turk *et al.*, Minkowski Tensor Shape Analysis of Cellular, Granular and Porous Structures, Adv. Mater. **23**, 2535 (2011)

Topical Talk DY 21.10 Wed 16:45 MA 144

Algorithms in statistical physics: Percolation — •Stephan Mertens[1,2] and Cristopher Moore[2,3] — [1]Otto-von-Guericke Universität, Magdeburg, Germany — [2]Santa Fe Institute, USA — [3]University of New Mexico, Albuquerque, USA

Statistical physics is a field rich in algorithmic challenges. In this contribution we discuss algorithms for the percolation problem. In particular we present a simple algorithm for generating percolating clusters. The algorithm works on lattices as well as in continuous systems, in arbitrary dimensions and even for heterogeneous objects. Despite its simplicity and versatility, the algorithm runs in linear time, which is the optimum for algorithms that explicitly construct percolating clusters. We use the algorithm to compute values of the percolation thresholds for various continuous systems with unprecedented accuracy.

DY 22: Posters I

Time: Wednesday 17:00–19:00 Location: Poster A

DY 22.1 Wed 17:00 Poster A

Associated Liquids from Electronic Structure Methods — •Eva Perlt, Marc Brüssel, Sebastian B. C. Lehmann, Michael v. Domaros, and Barbara Kirchner — Wilhelm-Ostwald-Institute for Physical and Theoretical Chemistry, University of Leipzig, Linnéstr. 2, D-04103 Leipzig, Germany

The investigation of liquid phases by means of electronic structure methods is still a demanding task due to the high computational cost and the large number of molecules that need to be considered. One approach modeling the liquid phase with the aid of statistical thermodynamics is the Quantum Cluster Equilibrium theory. In this contribution we present the basic methodology and its implementation in the Peacemaker program.[1] Furthermore, the extension of the theory to binary mixtures and the realization in the Mice code are introduced.[2] The application of the programs is demonstrated at the example of two case studies: The first deals with the structure of pure hydrogen fluoride. Therefor, explicitly correlated methods have been employed and a basis set extrapolation has been carried out. Second, the binary mixture of water and dimethyl sulfoxide at several mole fractions and the Excess Gibbs free energy of the mixture have been studied.

[1] B. Kirchner, C. Spickermann, S. B. C. Lehmann, E. Perlt, J. Langner, M. v. Domaros, P. Reuther, F. Uhlig, M. Kohagen, M. Brüssel, *Comp. Phys. Comm.* **182**, 1428-1446 (2011)

[2] M. Brüssel, E. Perlt, S. B. C. Lehmann, M. v. Domaros, B. Kirchner, *J. Chem. Phys.* **135**, 194113 (2011)

DY 22.2 Wed 17:00 Poster A

Free-Energy Fluctuations and Chaos in the Sherrington-Kirkpatrick Model — •Christoph Norrenbrock[1], Timo Aspelmeier[1], and Alexander K. Hartmann[2] — [1]Georg-August-Universität Göttingen, Göttingen (Germany) — [2]Carl-von-Ossietzky Universität Oldenburg, Oldenburg (Germany)

We consider the mean-field Ising spin glass (Sherrington-Kirkpatrick model [1]) regarding its sample-to-sample fluctuations of the free-energy. It has been shown [2] that these fluctuations are related to bond chaos, which refers to the property that the equilibrium state changes completely by an infinitesimal change of the bond strength. Taking this connection into account, it has been shown analytically using replica methods [2] that the exponent μ, governing the growth of the fluctuations with the system size N, is bounded by $\mu \leq \frac{1}{4}$.

In contrast to previous studies (e.g. [3]), where the fluctuations in the mean-field model were investigated numerically at zero temperature only, we calculate μ at finite temperature by simulating chaos. For this purpose, we compute spin-overlaps between systems with slightly different bond-assignments. These systems ($N = 16$ up to $N = 512$) were simulated by Monte-Carlo simulations using the parallel tempering method.

[1] Sherrington, D., Kirkpatrick, S., Phys. Rev. Lett. 35, 1792 (1975)
[2] Aspelmeier, T., Phys. Rev. Lett. 100, 117205 (2008)
[3] Boettcher, S., Eur. Phys. J. B 46, 501 (2005)

DY 22.3 Wed 17:00 Poster A

An entropy based model-free definition of causal coupling strength for multivariate time series — •Jakob Runge[1,2], Jobst Heitzig[1], and Jürgen Kurths[1] — [1]Potsdam Institute for Climate Impact Research, P.O. Box 60 12 03, D–14412 Potsdam, Germany — [2]Department of Physics, Humboldt University, Newtonstr. 15, D–12489 Berlin, Germany

We discuss the problem of defining a causal coupling strength between components of a multivariate time series if no underlying model is assumed. This is in contrast to methods like cross-correlation or granger causality. The method is based on conditional mutual information and utilizes the concept of graphical models. We investigate how our measure relates to model systems where a coupling strength is known and discuss its limitations.

DY 22.4 Wed 17:00 Poster A

Simulating flexible polymers in a potential of randomly distributed hard disks — Sebastian Schöbl, •Johannes Zierenberg, and Wolfhard Janke — Institut für Theoretische Physik, Universität Leipzig, Germany

Recently, we performed equilibrium computer simulations of a two-dimensional pinned flexible polymer exposed to a quenched disorder potential consisting of hard disks [1]. Throughout the study, we applied two conceptionally different algorithms, an off-lattice growth algorithm and a multicanonical Monte Carlo method, in order to cross-check the results obtained. We measured the the end-to-end distribution and the tangent-tangent correlations and investigated the scaling behavior of the mean square end-to-end distance for short chains. While the influence of the potential in the low-density case is merely marginal, it was possible to show that it dominates the configurational properties of the polymer for high densities.

[1] S. Schöbl, J. Zierenberg, and W. Janke, Phys. Rev. E 84, 051805 (2011)

DY 22.5 Wed 17:00 Poster A

Influence of rounding errors on the quality of heuristic optimization algorithms — •Martin Ransberger[1], Ingo Morgenstern[1], and Johannes Josef Schneider[2] — [1]Faculty of Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Department of Physics, Mathematics, and Computer Science, Johannes Gutenberg University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany

Simulated annealing and search space smoothing are both widely used optimization algorithms. While simulated annealing overcomes barriers in the energy landscape at finite temperatures, search space smoothing intends to remove these barriers, such that a greedy algorithm is sufficient to find the global minimum. Rounding errors in the calculation of the energy landscape can affect the quality of the results and even lead to a new physical behavior.

In this presentation, we thoroughly investigate the effect of rounding errors on the energy landscape and their influence on optimization processes with simulated annealing and search space smoothing. We present computational results for the traveling salesman problem.

DY 22.6 Wed 17:00 Poster A

Understanding water and water mixtures by phenomenological considerations — •Lotta Heckmann and Barbara Drossel — Institut für Festkörperphysik, TU Darmstadt, Germany

Understanding the behavior of water and water mixtures is of large relevance for biological systems. For this reason, the properties of bulk water, especially its phase behavior and its anomalies, have been subject of investigation until today. One approach to gain further insight into the special characteristics of water is the use of very simplified models that do not represent specific molecular properties, but rather aim to match general properties of water. We follow the spirit of Ben-Naim (2009) and investigate a 1D-model consisting of point masses and simple interaction potentials for which we analyze conditions under which a phase behaviour similar to that of water is observed. Since the model contains only very few parameters, we can thereby understand in more detail which ingredients are indispensable for a model that describes correctly the phase behaviour of water. Our long-term objective is to analyze the phase behaviour of water and water mixtures in confinement, for which we also perform molecular dynamics simulations.

DY 22.7 Wed 17:00 Poster A

Effects of hydrodynamic interactions in heterogeneous nucleation of colloids — •Dominic Röhm and Axel Arnold — Institute for Computational Physics, Universität Stuttgart, 70569 Stuttgart, Germany

Nucleation, the early stage of crystal growth, is still a rather poorly understood process. We investigated the heterogeneous nucleation in a colloidal model system near a wall using Molecular Dynamics computer simulations. In our coarse-grained simulations, the particles interact via a screened Coulomb (Yukawa-) potential representing charged colloids in water. Our focus lies on the influence of the hydrodynamic interaction, which is often neglected, since nucleation is considered as a quasi-static process. However, recent experiments have shown, that the kind of thermalization of the sample has a drastic influence on the nucleation rate.

In our simulations, we incorporated hydrodynamic nteractions by coupling the particles to a lattice fluid. Since the computation of the hydrodynamic interaction is still orders of magnitude more expensive than classical interactions, we have recently enabled our MD simulation software ESPResSo to employ GPUs for the calculation of the lattice fluid. By this, we can investigate systems, that previously required a small computer cluster, using a single GPU. Using a cluster equipped with GPUs, allows us to systematically investigate the influence of hydrodynamics on the heterogeneous nucleation, and explain why laminar flow conditions, can lead to enhanced nucleation by preordering.

DY 22.8 Wed 17:00 Poster A

Modelling Electrokinetic Phenomena with Lattice-Boltzmann and explicit Ions — •Georg Rempfer, Stefan Kesselheim, Dominic Röhm, and Christian Holm — Institute for Computational Physics, University of Stuttgart, 70569 Stuttgart, Germany

We report that we can successfully simulate electrokinetic phenomena like electro-osmotic flow in arbitrary geometries utilizing coarse-grained molecular dynamics simulations. We use point like particles to represent the ions, which interact via Lennard-Jones and Coulomb potentials. The long ranged Coulomb contribution is calculated with the P3M algorithm. To incorporate the hydrodynamic particle-particle and particle-wall interactions, we couple the point particles to a GPU accelerated, thermalized lattice-Boltzmann fluid. All implementations are readily available in the ESPResSo simulation package. With this method, we can successfully reproduce results obtained via the electrokinetic equations as demonstrated with slit-pore and cylindrical systems and we are able to treat systems beyond the validity of the electrokinetic equations like systems including multivalent ions.

DY 22.9 Wed 17:00 Poster A

Scale-free enumeration of self-avoiding walks on critical percolation clusters — •Niklas Fricke and Wolfhard Janke — Institut für Theoretische Physik, Universität Leipzig, Germany

We present a new method for exact enumeration of self-avoiding walks on critical percolation clusters. It can handle very long walks by exploiting the clusters' low connectivity and self-similarity. In 2D we were able to enumerate walks of more than 1000 steps with over 10^{170} conformations. The exponents ν and γ, governing the scaling behavior of the end-to-end distance and the number of configurations, as well as the connectivity constant μ could thus be determined with unprecedented accuracy. The method will help answering long-standing questions regarding this particular problem and might be extended to similar systems. Furthermore, it can be used to check and gauge other methods, analytical and numerical.

DY 22.10 Wed 17:00 Poster A

Nonlinear analysis of Diffusion Tensor Imaging (DTI) data of human brain neuron tracts — •Johanne Hizanidis[1], Panayiotis Katsaloulis[1], Dimitris Verganelakis[2], and Astero Provata[1] — [1]National Center for Scientific Research Demokritos, Athens, Greece — [2]Biomedical Institute Euromedica Encephalos, Athens, Greece

Magnetic Resonance Imaging (MRI) is a widely used medical non-ionizing and non-invasive imaging method for the accurate visualization of the human brain's internal. A recently developed MRI technique, the so-called Diffusion Tensor Imaging (DTI) Tractography allows the in-vivo spatial study of white matter neuronal fibers, with a resolution of the order of mm. DTI measures the local properties of water diffusion between the axons of the tracts producing 2D or 3D images, in which shape represents the architecture of fibers and color corresponds to the diffusion direction. In earlier studies, fractal geometries were employed to describe the architecture of the human brain. Fractal analysis was used to determine the degree of statistical self-similarity characterizing the neuron network corresponding to a certain part of the brain. In this work, we analyze the statistical properties of the local density distribution of water molecules in the brain, as obtained from the 3D DTI images and develop a nonlinear mathematical model to describe the dynamics of this structure which fit the real data. The quantitative measures extracted from the data could potentially be used as a diagnostic tool (index) enabling the discrimination between healthy and damaged (from accidents, diseases or age) white matter.

DY 22.11 Wed 17:00 Poster A

Desynchronizing effect of high-frequency stimulation in a generic cortical network model — Markus Schütt and •Jens Christian Claussen — Institut für Neuro- und Bioinformatik, Universität zu Lübeck

Transcranial Electrical Stimulation (TCES) and Deep Brain Stimulation (DBS) are two different applications of electrical current to the brain used in different areas of medicine. Both have a similar frequency dependence of their efficiency, with the most marked effects around 100 Hz. We apply superthreshold electrical stimulation, specifically depolarizing DC current, interrupted at different frequencies, to a simple model of a population of cortical neurons which uses phenomenological descriptions of neurons by Izhikevich and synaptic connections on a similar level of sophistication. With this model, we are able to reproduce the optimal desynchronization around 100Hz, as well as to predict the full frequency dependence of the efficiency of desynchronization, and thereby to give a possible explanation for the action mechanism of TCES.

[1] Markus Schütt and Jens Christian Claussen (submitted)

DY 22.12 Wed 17:00 Poster A

Auditory Stimulation to induce sleep slow oscillations — •Hong-Viet Ngo[1], Jan Born[2,3], Jens Christian Claussen[1], and Matthias Mölle[2,3] — [1]Institut für Neuro- und Bioinformatik, Univ. Lübeck — [2]Dept. of Neuroendocrinology, Univ. Lübeck — [3]Dept. of Medical Psychology and Behavioral Neurobiology, Univ.Tübingen

Slow oscillations, a hallmark of slow wave sleep, are collective cortical oscillations appearing in mammals during slow wave sleep, and have a typical spectral peak frequency around 0.8 Hz in humans. Recent studies have demonstrated a beneficial role of slow wave sleep for the consolidation of memories, which can even be enhanced by electrical stimulation [1]. Here, we use acoustical stimulation to probe to what extent an enhancement of slow oscillations is possible.

[1] L.Marshall, H.Helgadottir, M.Mölle, J.Born, Nature 444, 610 (2006)

DY 22.13 Wed 17:00 Poster A

Introducing Ca-dependent plasticity into cortical up/down-state models — •Michael Schellenberger and Jens Christian Claussen — Institut für Neuro- und Bioinformatik, Universität zu Lübeck

Multiple studies have shown that sleep and especially the so called slow wave sleep is essential for the development of memories. However the exact mechanisms remain unknown. Therefore we investigate a biophysical model proposed by Compte et al. [1] which shows those characteristic oscillations of the membrane voltage. We introduce long term plasticity due to a Ca-dependent plasticity rule, which is based both on the trafficking and the phosphorylation/dephosphorylation of AMPA-receptors in the postsynaptic spine. In different simulations we compare several aspects of the original and the modified model and investigate the dynamical properties of the neurons with respect to the generation of long term potentiation.

[1] A. Compte et al., J. Neurophysiol 89, 2707 (2003)

DY 22.14 Wed 17:00 Poster A

Multiscale entropy of heart rate fluctuations in patients with acromegaly — •Mirjana M Platiša[1], Svetozar Damjanović[2], and Vera Gal[1] — [1]Institute of Biophysics, School of Medicine, Belgrade University, Belgrade, Serbia — [2]Institute of Endocrinology, Clinical Center Serbia, Belgrade, Serbia

Recent evidence suggests that the loss of complexity in time-series may be a generic feature of pathologic dynamics. Hence, we have studied complexity of the time-series of heart interbeat (RR) intervals in patients with acromegaly using multiscale entropy (MSE). ECG was recorded during sleeping period in 10 patients with acromegaly (AP), and 7 age matched (AM) healthy subjects and 7 young healthy subjects. The whole data time-series of RR intervals were analyzed. The MSE curve profiles were different for these three groups. Complexity measure obtained over scale one is the highest in young healthy subjects and there is no difference between AP and AM subjects. However, at higher scales complexity is the highest in AP, and slightly higher in young subject than in AM group. These results reveal that long range heart rhythm complexity is significantly influenced by the excess of growth hormone.

DY 22.15 Wed 17:00 Poster A

Effects of mechanical motion on electrical excitation of the heart — •Stefan Fruhner[1,2], Harald Engel[1], and Markus Bär[2] — [1]Institut für Theoretische Physik, TU Berlin — [2]Physikalisch-Technische Bundesanstalt, Berlin

Computer models of cardiac excitation often include a very precise physiological description and accurately account for anatomical details like fibre orientation or heterogeneity of heart tissue but neglect cardiac motion. On the other hand it might be essential for a deeper understanding of the mechanisms of arrhythmias like tachycardia and fibrillation. To address this fact challenging mathematical approaches need to be implemented and thoroughly validated.

In this work we try to incorporate experimentally estimated motion into computer simulations. Time-resolved magnetic resonance images (MRI) were recorded in order to create finite element meshes that allow to map mechanical motion on statically performed simulations.

A tagged acquisition protocol was chosen so that cardiac motion can be extracted for a set of distinct points within the myocardial region. Myocardial fibre orientations were allocated algorithmically. Intra- and extracellular domains are treated separately utilizing a bidomain approach. The impact of cardiac motion on artificially generated biosignals like the electrocardiogram (ECG) or the magnetocardiogram (MCG) is demonstrated.

Our approach also offers the opportunity to calculate the mechanical stresses during cardiac contraction from experimental data.

DY 22.16 Wed 17:00 Poster A

Up- down state switching in a conductance- based cortical model — •Arne Weigenand, Thomas Martinetz, and Jens Christian Claussen — Institut für Neuro- und Bioinformatik, Universität zu Lübeck

Cortical slow oscillations occur in the mammalian brain during deep sleep and have been shown to contribute to memory consolidation, an effect that can be enhanced by electrical stimulation. As the precise underlying working mechanisms are not known it is desired to develop and analyze computational models of slow oscillations and to study the response to electrical stimuli. In this paper we employ the conductance based model of Compte *et al.* [J Neurophysiol **89**, 2707] to study the effect of electrical stimulation. First we reproduce the experimental results of electrical stimulation in ferret brain slices by Shu *et al.* [Nature **423**, 288] from the conductance based model. The electrical stimulation leads to collective responses which we observe to depend on the timing of the stimulus with respect to the state of the slow oscillation. To quantify the network response on stimulation we calculate the phase response curve for the conductance based network model. Within the up state stimulation leads to a shortening of the up state, or phase advance, whereas during the up-down transition a prolongation of up states is possible, resulting in a phase delay. Finally we derive the phase response curve also for the simple mean-field

model by Ngo *et al.* [epl Europhysics Letters **89**, 68002] and find that the qualitative shape is preserved.
[1] A. Weigenand, T. Martinetz and J.C. Claussen, submitted

DY 22.17 Wed 17:00 Poster A

Rigorous selection theory of free dendritic growth in a flow — •Martin von Kurnatowski and Klaus Kassner — Otto-von-Guericke-University Magdeburg, Department of Theoretical Physics, Universitätsplatz 2, 39106 Magdeburg

The problem of a crystal growing freely in its undercooled melt is governed by heat transport. The two-phase boundary takes a nearly parabolic shape. This dendrite is stabilized by *anisotropic* surface tension which acts as a singular perturbation and selects the growth velocity and the length scale of the pattern. So far, the selection problem has usually been treated with the Kruskal-Segur-method [1], which is only applicable to linear field equations.
We extend this method with the asymptotic Zauderer decomposition scheme. This powerful combination is able to deal with many unsolved problems in crystal growth such as *nonlinear* convective effects. An equation determining the shape of the dendrite is derived from the diffusion-advection equation. Only at this point, a particular flow velocity field has to be inserted, which we approximate as a potential flow. Subsequently, a solution to this equation is constructed by asymptotic matching in the complex plane using WKB techniques. Shape and growth velocity are finally selected by numerical integration of a local equation close to the singular point of the problem.

[1] M. Ben Amar, Phys. Rev. A 41, p. 2080 (1990)

DY 22.18 Wed 17:00 Poster A

Biofilm growth in shear flows — •Jörn Hartung and Björn Hof — Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen

The formation of biofilms in water distribution systems and medical equipment has detrimental effects (e.g. decrease in efficiency of water conduits and emergence of health risks). Pathogenic microorganisms capable of biofilm formation can spoil potable water and easily lead to infections in humans. Furthermore, biofouling in water distribution pipes decreases the cross section available for the bulk flow and increases the surface roughness which in turn leads to higher friction losses.

We investigate the influence of the Reynolds number on biofilm formation for laminar flow in the regime 500<Re<5000. While generally biofilms grow faster at low Reynolds numbers where the shear stresses are small, we surprisingly find a maximum growth for 1000<Re<2000. An explanation for this behaviour could be that the transport rate of nutrients is limited at small Reynolds numbers leading to lesser amounts of attached biofilm material. At increasing Reynolds numbers shear forces become more pronounced and facilitate detachment. At high Reynolds number we find in addition that the biofilms disturb the initially laminar flow and trigger turbulence which leads to a large drag increase.

DY 22.19 Wed 17:00 Poster A

The Three-Body Model of a Micro-swimmer — •Jayant Pande[1], Kristina Pickl[2], Jan Götz[2], Klaus Iglberger[3], Klaus Mecke[1], Ulrich Rüde[2,3], and Ana-Sunčana Smith[1] — [1]Institut für Theoretische Physik, Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Lehrstuhl für Systemsimulation, Universität Erlangen-Nürnberg, Erlangen, Germany — [3]Zentralinstitut für Scientific Computing, Universität Erlangen-Nürnberg, Erlangen, Germany

Engineered micro-devices which are capable of moving alone through a fluid can be of crucial importance in various fields of science. The simplest model of such a micro-device has been introduced by Najafi and Golestanian, and consists of three spheres connected by two arms which move in a non time-reversible fashion. This geometry has been analyzed by Golestanian and Ajdari and by Felderhof, under the assumption that the deformations of the swimmer's arms and the forces driving them are known, respectively. We expand these two approaches by taking higher order terms into account, and find the regime of their agreement. For sinusoidal driving forces, we show that the movement of the arms is restricted by the geometrical parameters, which imposes an upper bound on the velocity. We also extend the three-sphere model by replacing some or all of the spheres in the swimmer by cylindrical capsules, thus introducing some inherent asymmetry to the swimmer design, thereby affecting the swimming efficiency. All analytical results are presented in conjunction with those from a simulation framework employing a rigid-body engine coupled to a Lattice-Boltzmann fluid solver.

DY 22.20 Wed 17:00 Poster A

Motions of aligned object with adjustable chiralities in the stirring-driven flow under the low Reynolds number condition. — •Sung-chih Su and Peilong Chen — No.300, Jhongda Rd., Jhongli City, Taoyuan County 32001, Taiwan (R.O.C.)

Chiral structures of organisms or molecules influence their migration. To study the relation between the structure and the dynamic of a chiral object, we have observed the motion of a chiral sample which moves in a driven flow under the low Reynolds number condition (Re ~0.1). The sample is a three-piece *H* shape object (size is 2cm) whose center stick always aligns in the vertical direction. A vertical rod that revolves in a cylindrical container (radius=10cm) stirs the liquid inside (depth=20cm). On the top view, this sample has the *X* shape with a crossing angle ranging from -90 to 90 degrees, and an intrinsic orientation was defined by the angle bisector. The handedness of a sample depends on the sign of the crossing angle. Under the temperature control and density match, the trajectories in the frame rotating with driving rod are steady closed loops on the horizontal plane with their size expanding with the absolute value of the crossing angle. A pair of samples with opposite handedness has the same spin frequency with the driving rod. Their intrinsic orientations also have the same dependence on spatial position except for the absolute value of the crossing angle ranging between 70 to 85 degrees in which the opposite handed ones have a difference in their intrinsic orientations. We also observe the coupled trajectories and spins of two chiral objects.

DY 22.21 Wed 17:00 Poster A

Molecular dynamics simulations of capillary rise in nanochannels — •Christian Thome and Heiko Rieger — Theoretische Physik, Universität des Saarlandes, Campus E2 6, D66123 Saarbrücken

The capillary rise of liquid-air interfaces, so called menisci, in nanometer scale pores displays time-dependencies that deviate from macroscopic laws like Lucas-Washburn. Motivated by experiments on the spontaneous imbibition in nano-porous vycor glass we study with the help of molecular dynamics simulations the capillary rise of fluid in nano-pores, nano-pore-junctions and nano-pore-intersections. We focus on the quantitative characterizaion of the influence of the wall / fluid particle interaction strength and present results for the fluid propagation, interface morphology and fluid density fluctuations.

DY 22.22 Wed 17:00 Poster A

Strömungsfeld und Widerstand bei der Bewegung von Luftblasen in einer Flüssigkeit. — •Heinz Preuss — 31785 Hameln, Sedanstr. 6

In einer als Fall- bzw. Steigrohrviskosimeter gestalteten transparenten Flasche mit Duschgel konnten Vergleichsmessungen zur Bewegung von Luftblasen und von Kugeln aus Stahl und Quarz durchgeführt werden (s. Vortrag DD16.6 Münster 2011). Für beide Arten von Versuchskörpern konnte die für Newton'sche Flüssigkeiten charakteristische quadratische Abhängigkeit der Steig- bzw. Sinkgeschwindigkeit vom Kugeldurchmesser gefunden werden. Der Bewegungswiderstand erwies sich aber für Luftblasen als nur halb so groß wie für starre Versuchskörper. In Anlehnung an die analytische Herleitung der Stokes-Beziehung ($Fw=6\pi\eta Rv$) durch Sommerfeld (Arnold Sommerfeld, Vorlesungen über theoretische Physik, Band 2: Mechanik der deformierbaren Medien. Leipzig 1945, S. 237 ff., neu bei: Harri Deutsch 1992) wird nach Abänderung der Grenzbedingungen das Geschwindigkeitsfeld um die bewegte Luftblase berechnet und mit dem Geschwindigkeitsfeld um eine starre Kugel verglichen. Es wird der Versuch der Herleitung einer modifizierten Stokes-Beziehung mit Faktor 3 statt 6 diskutiert.

DY 22.23 Wed 17:00 Poster A

DDES Simulation of the turbulent wake of a fractal square grid — Hannes Hochstein[1], Stefan Weytemeier[1], Bernhard Stoevesandt[2], and •Joachim Peinke[1] — [1]ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg — [2]IWES - Fraunhofer Institute for Wind Energy and Energy Systems

The wake of the flow through a fractal square grid was simulated, using the open-source CFD code OpenFOAM. In 2007, Hurst published an article about fractal grids. Those grids produce turbulence on a range of different scales, which influent each other, and have very different properties than all previously documented turbulent flows and is even considered to define a new class of turbulence. This turbulence is able to keep its homogenity and isotropy further downstream than classical, one-scale-generated turbulence. This, and the fact that real wind energy converters are exposed to multi-scale turbulence, makes the fractal generated turbulence interesting as inflow boundary condition for a CFD simulation of a wind energy converter.

The simulation was carried out using the delayed detached eddy simulation (DDES) of OpenFOAM. The goal of the work was to simulate the governing anomalous turbulence properties qualitively, to maintain their good usability as a inflow boundary condition. The first results of the simulation were compared with similar wind tunnel experiment data, which showed a pretty good agreement of the main turbulence properties like turbulence intensity, skewness and flatness of the flow velocity.

DY 22.24 Wed 17:00 Poster A

Gaussian vortex approximation to the instanton equations of two-dimensional turbulence — •Kolja Kleineberg and Rudolf Friedrich — Institute for Theoretical Physics, University of Münster, Germany

We investigate two dimensional turbulence within the instanton formalism. The instanton formalism determines the most probable field in a stochastic classical field theory starting from the Martin-Siggia-Rose path integral. To this end, we derive a history dependent equation for the Langrangian velocity and vorticity field using a point vortex approach. A variational ansatz using elliptical vortices leads to a set of evolution equations for the positions and the shapes of the vortices. We discuss the relationship of this dynamical system to the inverse cascade process of two-dimensional turbulence.

DY 22.25 Wed 17:00 Poster A

Fraktale Beschreibung turbulenter Windfelder — •Martin Menke — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg

Mit Hilfe eines Modells zur generation einer fraktalen Grenzfunktion sollen turbulente Windfelder charakterisiert werden. Es wird auf den Zusammenhang zwischen dem geschlossenen analytischen Ausdruck einer solchen Grenzfunktion und einer Weierstraß-Mandelbrot-Funktion eingegangen. Desweiteren wird die Analyse und Auswertung turbulenter Daten in Form intermittenter Verteilungen der Geschwindigkeitsinkremente, Strukturfunktionen und Energiespektren berücksichtigt.

DY 22.26 Wed 17:00 Poster A

New anemometers for turbulent flow measurements on different scales — •Hendrik Heisselmann, Jaroslaw Puczylowski, Michael Hölling, and Joachim Peinke — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg

Experimental investigations of turbulent flows are an essential tool for the characterization of turbulence and the validation of simulations. Therefore, highly resolving and robust sensors are needed for different length scales.

We present two new drag-based sensors developed at the University of Oldenburg, which make use of the laser pointer principle also known from atomic force microscopy. This technique allows for the detection of small displacements of a sphere in case of the *sphere anemometer* and the deflection of a tiny cantilever in case of the *2D Laser-Cantilever-Anemometer* (2D LCA), respectively.

The *2D LCA* was developed for measurements on small scales of turbulent flows in two dimensions with high temporal resolution comparable x-wire anemometry. We present data acquired with a cantilever on the scale of $35\,\mu m \times 140\,\mu m$ (width × length) in turbulent laboratory flows and compare it to data from a commercial x-wire anemometer.

As an alternative to standard sensors for wind energy applications, the new *sphere anemometer* was designed for the simultaneous two dimensional measurement of turbulent atmospheric flows on a spatial scale of several cm. In our contribution, comparative measurements in turbulent flows performed with sphere anemometer, cup anemometer and sonic anemometers will be presented.

DY 22.27 Wed 17:00 Poster A

Directed percolation model for turbulence transition in shear flows — •Korinna Allhoff[1] and Bruno Eckhardt[2] — [1]Institut für Festkörperphysik, TU Darmstadt — [2]Fachbereich Physik, Philipps-Universität Marburg

We analyze a 1+1-dimensional directed percolation system as a model for the spatio-temporal aspects of the turbulence transition in pipe flow and other shear flows. Space and time are discrete, and the model is characterized by two parameters: one describes the probability to remain turbulent in the next step, the other characterizes the spreading of turbulence to the neighboring cells. The transition to a persistent turbulence is evident in mean field arguments, but the actual values are considerably renormalized by fluctuations. Extensive numerical tests show that the model falls into the universality class of one-dimensional directed percolation. We conclude with a discussion of the spreading of localized perturbations and an extension to two-dimensional systems.

DY 22.28 Wed 17:00 Poster A

Detached-Eddy Simulation of the MEXICO wind turbine with OpenFOAM — •Henry Plischka, Ivan Herraez, Bernhard Stoevesandt, and Joachim Peinke — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg

A better understanding of wind turbines aerodynamics is necessary to increase the overall energy yield achieved by wind turbines.It also plays a crucial role in reducing the loads on the wind turbine blades and the whole structure. In this scope we conducted the present work which is a part of the project MexNext IEA Wind (Task 29). A very important part of this investigation is the analysis of the radial component of the velocity on the wind turbine blades. Indeed, it seems that this radial velocity yields to a vortex located at the middle of the blade. To gain a more detailed insight on the physics of such a secondary flow, a Detached Eddy Simulation (DES) was conducted with the open source CFD-software OpenFOAM. The simulations were validated with wind tunnel measurements of the MEXICO project and with CFD-simulations from other partner institutions of the MexNext project.

DY 22.29 Wed 17:00 Poster A

Identifying Heat Transport Processes in Turbulent Rayleigh-Bénard Convection via a PDF Equation Approach — •Johannes Lülff[1], Richard J.A.M. Stevens[2], Michael Wilczek[1], Rudolf Friedrich[1], and Detlef Lohse[2] — [1]Institute for Theoretical Physics, University of Münster, Wilhelm-Klemm-Straße 9, 48149 Münster, Germany — [2]Department of Science and Technology and J. M. Burgers Center for Fluid Dynamics, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

Rayleigh-Bénard convection, i.e. the convection of a fluid enclosed between two plates that is driven by a temperature gradient, is the idealized setup of a phenomenon ubiquitous in nature and technical applications. Of special interest for this system are the statistics of turbulent temperature fluctuations, which we are investigating for a fluid enclosed in a cylindrical vessel.

To this end, we derive an exact evolution equation for the probability density function (PDF) of temperature from first principles. Appearing unclosed terms are expressed as conditional averages of velocities and heat diffusion, which are estimated from direct numerical simulations.

Our theoretical framework allows to connect these statistical quantities to the dynamics of Rayleigh-Bénard convection, giving deeper insights into the temperature statistics and transport mechanisms in different regions of the fluid volume, i.e. in the boundary layers, the bulk and the sidewall regions.

DY 22.30 Wed 17:00 Poster A

Functional renormalisation flow equation for Burgers' equation — •Steven Mathey, Jan Martin Pawlowski, and Thomas Gasenzer — Institut für theoretische physik, Universität Heidelberg, Heidelberg, Germany

The stochastic Burgers' equation is studied as a toy model for Navier-Stokes turbulence. Starting from the "quantum" effective action we derive renormalisation flow equations for the viscosity and the correlation functions. We investigate the different fixed points.

DY 22.31 Wed 17:00 Poster A

Time-delayed and spatially nonlocal feedback control of front or pulse propagation — •Anna Kuznetsova, Markus A. Dahlem, and Eckehard Schöll — Institut für Theoretische Physik, TechnischeUniversität Berlin, Berlin, Germany

We study spatio-temporal dynamics of front or pulse propagation in reaction-diffusion systems with time-delayed or spatially non-local feedback control in one spatial dimension. We consider one- or two-variable reaction-diffusion models with cubic nonlinearity (the Schlögl model and the FitzHugh-Nagumo model). We investigate the effects of a time-delayed and spatially nonlocal feedback control on the speed of the front or pulse propagation in dependence on the time scale separation parameter ε and construct bifurcation diagrams as a function of ε.

Supported by DFG through SFB 910.

DY 22.32 Wed 17:00 Poster A

Applications of variable delay dynamics: Stability of regenerative chatter in machining with spindle speed variation — •Andreas Otto and Günter Radons — Institute of Physics, 09107 Chemnitz, Germany

Undesired vibrations in machining cause poor surface finish, increased tool wear, noise and machine tool damage. The main reason are unstable self-excited vibrations, which are called regenerative chatter. In this sense the chatter stability limit is an upper bound for the material removal rate.

Regenerative chatter in machining processes can be modeled by delay differential equations, where the value of the time delay is related to the period of rotation of the workpiece or cutting tool spindle. The implementation of an active spindle speed variation enables the modulation of a time-varying delay which can stabilize unstable chatter vibrations and allows stable cutting processes with higher material removal rates.

A method for an approximation of the chatter stability limit [1] is presented, which gives a simple connection between the stability limit for constant and time-varying delay. It can be used to estimate the efficiency or to find optimal parameters of the spindle speed variation.

[1] A.Otto, G. Kehl, M. Mayer and G. Radons, Stability analysis of machining with spindle speed variation, *Adv. Mater. Res.* **223**, 600-609 (2011).

DY 22.33 Wed 17:00 Poster A

Complex behavior in diffusively coupled systems with variable delay — •Jian Wang and Günter Radons — Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany

In ubiquitous natural and laboratory situations the action of time delayed signals is a crucial ingredient to understand the dynamical behavior of these systems. A frequently encountered situation is that the length of the delay time changes with time. With the introduction of varying delay, a simple system can exhibit complicated behavior. In this study, we consider diffusively coupled extended systems, including coupled map lattice models and reaction diffusion equations, and investigate the system dynamic of such systems with variable delay. Lyapunov exponents and dynamical structure factors are calculated. Various classes of observed space-time structures are characterized and compared to the situation with constant delay.

DY 22.34 Wed 17:00 Poster A

Stability of frequency-locked solutions on a ring of coupled phase oscillators with distributed delays — •Lucas Wetzel[1], Saul Ares[1], Luis G. Morelli[2], Andrew C. Oates[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Max Planck Institute of Molecular Cell Biology and Genetics

We study systems of identical coupled phase oscillators, introducing a delay distribution that weights the contributions to the coupling arising from different past times. We have previously shown that for any coupling topology where each oscillator has an equal number of neighbors, the frequency and stability of the phase-locked solutions only depend on the first moment of the delay distribution.

In this contribution I will explore the stability of frequency-locked solutions where all oscillators synchronize to a common global frequency, but keep constant nonzero phase differences with respect to one another. We find analytical expressions, confirmed through numerical simulations, for the stability and conclude that distributed delays can change the stability of frequency-locked solutions.

DY 22.35 Wed 17:00 Poster A

Wave nucleation and stabilization in curved media — •Frederike Kneer, Sebastian Boie, Eckehard Schöll, and Markus A. Dahlem — Institut für Theoretische Physik, TU Berlin

We analyzed nucleation of wave segments on curved two-dimensional excitable media stabilized by feedback control. As a generic model of excitation waves in reaction-diffusion media, we used a FitzHugh-Nagumo system in 2 spatial dimensions. In order to find the nucleation threshold, we used feedback control on deformed excitable media such as tori or flat surfaces with local humps or folds. The main results are twofold. First, investigating excitation waves on a torus, we show that the Gaussian curvature of the excitable medium changes the nucleation threshold in a systematic way, i.e. on a negative Gaussian curved area the nucleation size is smaller (higher excitability). Second, and more surprisingly, we observed that a positive Gaussian curvature can even induce a change of stability. We are motivated to study excitation waves in deformed media by neuronal waves in the folded cortex.

DY 22.36 Wed 17:00 Poster A

Surfactant-induced gradients in the 3D Belousov-Zhabotunsky reaction — •Dennis Kupitz[1], Sergio Alonso[2], Markus Bär[2], and Marcus Hauser[1] — [1]Abteilung Biophysik, Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Germany — [2]Physikalisch-Technische Bundesanstalt, Fachbereich 8.4, Berlin, Germany

Scroll waves are prominent patterns formed in 3D excitable media, and they have been found to be at the basis of some types of cardiac arrhythmias. Experimentally, scroll waves dynamics is often studied by optical tomography in the Belousov-Zhabotinsky reaction, which produces CO_2 as an undesired product. Addition of small concentrations of a surfactant is a popular method to suppress or retard CO_2 bubble formation. We report that in closed reactors even these low concentrations of surfactants are sufficient to generate vertical gradients of excitability which are due to gradients in CO_2 concentration. In reactors open to the atmosphere such gradients can be avoided. Gradients are shown to induce a twist onto vertically oriented scroll waves, while a twist is absent in scroll waves in a gradient-free medium. The effects of the CO_2 gradients are explained by a numerical study, where we modified the Oregonator model to account for the production of CO_2 and for its advection against the direction of gravity. The numerical simulations confirm the role of solubilized CO_2 as the source of the vertical gradients of excitability in reactors closed to the atmosphere.

[1] D. Kupitz, S. Alonso, M. Bär, M.J.B. Hauser, Phys. Rev. E 84, 056210 (2011).

DY 22.37 Wed 17:00 Poster A

Interaction between a scroll wave and a perpendicular gradient — •Patricia Dähmlow and Marcus Hauser — Abteilung Biophysik, Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Germany

Scroll waves are the 3D counterparts of spiral waves occurring in excitable media. They play an important role in the formation of cardiac arrhythmias like ventricular tachycardia and fibrillation. In the heart, gradients are often introduced by the layering of heart tissue; however scroll waves may adopt any orientation with respect to these gradients.

The dynamics of scroll waves is sensitive to gradients of excitability that have a component parallel to the filament of the scroll [1]. Such gradients may induce a twist in the scroll. Using optical tomography, we investigate the interaction of a scroll wave in the Belousov-Zhabotinsky reaction with a gradient of excitability oriented perpendicularly to the filament. Perturbations of the originally perpendicular orientation between filament and gradient twist the scroll wave. When this process sets in at the two ends of the filament, the scroll wave suffers twists of opposite handiness, which form a nodal plane, where the scroll remains untwisted.

[1] C. Henze, E. Lugosi, A.T. Winfree, Can. J. Phys. 68, 683 (1990)

DY 22.38 Wed 17:00 Poster A

Local coupling of non-linear oscillators studied in the Bhelousov-Zhabotinsky reaction — •Claudia Lenk[1], Mario Einax[2], Philipp Maass[2], and Michael Koehler[1] — [1]Institut für Chemie und Biotechnik, Technische Universität Ilmenau, Germany — [2]Fachbereich Physik, Universität Osnabrück, Germany

Pattern formation in reaction-diffusion (RD) systems is important in many areas as, for example, embryonic development, catalytic activity or population dynamics. These systems commonly exhibit a modular structure with coupled subunits, like the cells of the embryo. To investigate the influence of the modular structure onto the dynamical patterns in RD systems we conduct experiments of the Bhelousov-Zhabotinsky reaction in a Nafion® membrane or a silica gel with a structured catalyst distribution and compare them with corresponding numerical studies of the FitzHugh-Nagumo equations. In particular we analyse the influence of the oscillator size, distance and shape onto the strength of the coupling between neighbouring spots of high catalyst concentration. In dependence of the oscillator distance, a bifurcation into two different patterns, a spiral wave and a target pattern, is found. Generally the emerging dynamical patterns depend sensitively on the initial conditions and we present first results for predicting the type of dynamical pattern.

DY 22.39 Wed 17:00 Poster A

Dynamics of scroll rings in confined geometry — •Arash Azhand, Teresa Reinhard, Rico Buchholz, and Harald Engel — Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, EW 7-1, D- 10623 Berlin

The undamped propagation of three-dimensional travelling waves has been observed in a variety of dissipative active media including chemical waves, temperature waves in solid fuel combustion, and waves of electric activity in heart tissue, for example. We study modifications to the intrinsic dynamics of such scroll waves caused by perturbations originating from the surrounding boundaries during wave propagation in confined geometry. In particular, we focus on the evolution of scroll rings interacting with Neumann type boundaries in thin layers of the photo-sensitive Belousov-Zhabotinsky reaction. The experimental results are compared to numerical simulations with the underlying Oregonator model.

DY 22.40 Wed 17:00 Poster A

Fluctuations, linear response and heat flux of an aging system — Juan Ruben Gomez-Solano[1,2], •Artyom Petrosyan[1], and Sergio Ciliberto[1] — [1]Laboratoire de Physique (UMR CNRS 5672), ENS de Lyon, 46, allée d'Italie, F-69364 Lyon CEDEX 07, France. — [2]Current address: Universität Stuttgart, 2. Physikalisches Institut Pfaffenwaldring 57, 70569 Stuttgart, Germany.

We experimentally measure the fluctuations of the position of a colloidal particle confined bz an optical trap in an aging gelatin after a fast quench and its linear response to an external perturbation. We compute the spontaneous heat flux from the particle to the bath due to the nonequilibrium assemblage of the gel. We show that: 1) the heat fluctuations satisfy the fluctuation theorem and 2) the mean heat flux is quantitatively related to the violation of the fluctuation-dissipation theorem as a measure of the broken detail balance during the aging process.

DY 22.41 Wed 17:00 Poster A

Limited validity of the transient fluctuation theorem for instantaneous entropy differences in Langevin dynamics — •Hendrik Niemeyer and Jochen Gemmer — Universität Osnabrück, Barbarastraße 7, D-49069 Osnabrück

We investigate the validity of the transient fluctuation theorem for entropies which are only a function of the current state of the system (”instantaneous entropies”). While it is a well-known fact that the transient fluctuation theorem always holds for Langevin systems in non-equilibrium steady states (Kurchan, 1998) this is not true for Langevin systems featuring exponential relaxation and a naturally arising instantaneous entropy defintion which is quadratic in the observable of interest. The transient fluctuation theorem then only holds in the limit of small observation times and small entropy defintions starting far away from equilibrium.

DY 22.42 Wed 17:00 Poster A

Driven transport in lattice gases with nearest-neighbor interactions and general couplings to particle reservoirs — •Marcel Dierl, Philipp Maass, and Mario Einax — Fachbereich Physik, Universität Osnabrück, Barbarastraße 7, 49076 Osnabrück, Germany

Nonequilibrium steady states of lattice gases with nearest-neighbor interactions are studied that are driven between two reservoirs. A generic feature of these systems is the emergence of density oscillations close to the system boundaries. These oscillations lead to phases of the bulk density which cannot be predicted by the minimum and maximum current principles. These principles are suited only for very special bulk-adapted couplings of the system to the reservoirs. It is shown that an approach based on time-dependent density functional theory can cope with the density oscillations and successfully predicts phase diagrams of bulk densities to a good approximation under arbitrary boundary-reservoir couplings.

DY 22.43 Wed 17:00 Poster A

Fluctuation of work and heat of the isothermal expansion of an ideal gas — •Johannes Hoppenau and Andreas Engel — Institut für Physik, Carl von Ossietzky Universität, 26111 Oldenburg

Recently stochastic thermodynamics gave rise to unexpected results, such as the Jarzynski equation. The Jarzynski equation relates the average exponential work done under an non-equilibrium transformation to the difference of the free energy between the end and start state. As in illustrative example we present a model for the isothermal expansion and compression of an ideal gas and investigate the probability of the work done and the heat transferred during the transformation. Lua and Grosberg did an similar analysis for an adiabatic expansion and compression. Both results together may be used to investigate the efficiency of an Carnot cycle far from the quasi static limit.

DY 22.44 Wed 17:00 Poster A

Nonlinear Dynamics of Coupled Oscillators with Localized Energy Dissipation — •Rita Leite and Lutz Schimansky-Geier — Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin

In this work we investigate the thermally activated transition dynamics of a harmonically coupled one-dimensional oscillator chain. In contrast to previous work [Henning et al., EPL (2007)], in which the collective escape dynamics of purely deterministic system initiated/supported by modulation instability (Breathers) [Dauxois et al., Phys. Rev. Lett., Vol. 70 (1993)] has been considered, in our model, the oscillator chain is coupled to an external heat bath. The latter is modeled by a single Brownian particle evolving a purely harmonic on-site potential. The units of the oscillator chain evolve/are located in a one-dimensional, nonlinear, asymmetric on-site potential and they are not affected by the effects of damping and noise.

Depending on the chosen boundary conditions (open or periodic boundary conditions), we observe a resonance behavior of the average crossing time as a function of the coupling strength κ. In the weak coupling limit the fluctuations of the heat bath are only weakly transferred to the chain and consequently crossing events are rare. With increasing coupling the system is thermalized rapidly, resulting in a minimum of the average crossing time. The latter increases proportional to e^{κ} with further growing coupling strength. Spatially localized modulation instability can not be detected in this model for the chosen anharmonicity parameter and fluctuation strength.

DY 22.45 Wed 17:00 Poster A

Stochastic description of a bistable frustrated unit — •Hannes Nagel[1], Wolfhard Janke[1], and Hildegard Meyer-Ortmanns[2] — [1]Institut für theoretische Physik, Universität Leipzig, Postfach 100920, D-04009 Leipzig — [2]School of Engineering and Science, Jacobs University Bremen, P.O. Box 750561, D-28725 Bremen

Coupled positive and negative feedback loops are often found in biological systems that support oscillations. Here we consider genetic regulatory circuits. Two species of proteins A and B interact by activation/repression of their respective expression: A activates the production of itself as well as that of B, which in turn represses A. Starting from a previous deterministic study of that model we chose a fully stochastic approach to learn about the effect of the inherent noise in such (typically small) systems.

DY 22.46 Wed 17:00 Poster A

Glassy dynamics of kinks in stripe phases — •Christian Riesch, Günter Radons, and Robert Magerle — Institut für Physik, Technische Universität Chemnitz, D-09107 Chemnitz, Germany

The formation of stripes can be observed in many physical systems, including block copolymers, thin magnetic films and Rayleigh-Bénard convection. We investigate numerically the dynamics of two well-known models of stripe formation, the diblock copolymer equation and the Swift-Hohenberg equation. The systems are prepared in an ordered initial state consisting of parallel stripes, which is then subjected to thermal fluctuations during the simulation. We find that already a small amount of noise is sufficient to induce a characteristic glassy dynamics, which is revealed in time correlation functions of the local stripe orientation as well as the local curvature. We attribute this glassy behavior to the fluctuation of kinks in the stripes. Both correlation functions are found to scale as $C(t, t_w) \sim t_w^{-b} \cdot f(t/t_w)$, a scaling form commonly found in other glass-forming systems.

DY 22.47 Wed 17:00 Poster A

Mean-field approach to coherence resonance in a coupled oscillator systems — •Paul Geffert, Valentin Flunkert, and Eckehard Schöll — Technische Universität Berlin, Germany

Many nonlinear systems exhibit noise-induced oscillations, when driven by a stochastic force. Coherence resonance – the optimal coherence of oscillations at a certain noise strength – is ubiquitous in these systems and has important applications.

We discuss coherence resonance in a generic Hopf normal form model inspired by a laser system. By applying a mean field approximation, we obtain analytic expressions for the correlation time and the signal to noise ratio. Using the same tools, we discuss noise induced oscillations of two coupled Hopf normal form systems.

We find that with a low noise intensity in one system it is possible to control the correlation time and the full width at half maximum only with the noise from the coupled oscillator.

DY 22.48 Wed 17:00 Poster A

Complex Dynamics of Quantum Dot Lasers Under Optical Injection — •Christian Otto, Johannes Pausch, Kathy Lüdge, and Eckehard Schöll — Technische Universität Berlin, Germany

We study the influence of nonlinear carrier lifetimes on the complex dynamics of a quantum dot (QD) laser under optical injection.

The dynamics of a QD laser is crucially affected by the damping rate of its turn-on relaxation oscillations, which in turn is determined by the carrier lifetimes in the QDs. We derive the carrier lifetimes by microscopical calculations of the Coulomb scattering rates between the discrete QD levels and the surrounding quantum well acting as a carrier reservoir. This yields non-constant and unequal carrier lifetimes for electrons and holes in the QDs, which are nonlinear functions of the reservoir carrier densities.

Depending on the band-structure, the lifetimes of electrons and holes in the QDs can be similar or drastically different. Further they can be fast or slow compared to the carrier lifetimes in the carrier reservoir. We study the locking behavior as well as more complex bifurcation scenarios close to the boundaries and outside of the locking region. The dynamics is investigated by means of direct numerical integration and path continuation techniques.

A stronger damping of the turn-on relaxation oscillations leads to smaller regions of complex dynamics and enlarges the range of stable frequency-locked continuous wave operation. An optimal value of the carrier lifetimes is found that maximizes the range of stable operation.

DY 22.49 Wed 17:00 Poster A

Attractor dimension at the transition to chaos synchronization for networks with time-delayed couplings — •Steffen Zeeb and Wolfgang Kinzel — Theoretische Physik III, Universität Würzburg

A network of nonlinear units interacting by time-delayed couplings can synchronize to a common chaotic trajectory. Although the transmission time may be very long the units are completely synchronized without time shift.

We investigate the attractor dimension at this transition to complete chaos synchronization. In particular, for networks of iterated maps we determine the Kaplan-Yorke dimension from the spectrum of Lyapunov exponents which is calculated analytically for Bernoulli maps and numerically for Tent maps. However, we argue that the Kaplan-Yorke conjecture cannot be true at the transition. For the synchronized state the Lyapunov exponents perpendicular to the synchronization manifold cannot contribute to the attractor dimension. Consequently, the Kaplan-Yorke dimension has to be discontinuous at the transition. We calculate the magnitude of this jump for different networks.

The Kaplan-Yorke dimension is an upper bound for the correlation dimension. Using the method of Grassberger & Procaccia we calculate the correlation dimension for networks of iterated Bernoulli and Tent maps. For Bernoulli networks the correlation dimension jumps at the transition to synchronization whereas for Tent maps the correlations dimension is continuous. We conclude that for some systems the Kaplan-Yorke conjecture yields qualitatively incorrect results.

DY 22.50 Wed 17:00 Poster A

Geometry of inertial manifolds probed via a Lyapunov projection method — •Hong-liu Yang[1] and Günter Radons[2] — [1]Institute of Mechatronic, D-09126 Chemnitz, Germany — [2]Chemnitz University of Technology, D-09107 Chemnitz, Germany

A method for determining the dimension and state space geometry of inertial manifolds of dissipative extended dynamical systems is presented. It works by projecting vector differences between reference states and recurrent states onto local linear subspaces spanned by the Lyapunov vectors. A sharp characteristic transition of the projection error occurs as soon as the number of basis vectors is increased beyond the inertial manifold dimension. Since the method can be applied using standard orthogonal Lyapunov vectors, it provides a simple way to determine also experimentally inertial manifolds and their geometric characteristics.

DY 22.51 Wed 17:00 Poster A

Singularities in the delay-time distribution of 2D scattering systems — •Stefan Majewsky[1] and Holger Schanz[2,3] — [1]Computational Physics Group, Technische Universität Dresden, Institut für Theoretische Physik, 01062 Dresden — [2]Institut für Maschinenbau, Hochschule Magdeburg-Stendal, 39114 Magdeburg — [3]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden

We investigate scattering systems where the probability distribution of the time delay shows logarithmic singularities and thus a clustering of delay times near some system-specific values. The effect can be understood as a generalization of caustics to the time domain. Its dynamical origin are saddle points in the time delay function. They arise either due to the details of the dynamics in the scattering region or, in some trivial cases, as a side-effect of a coordinate transformation. We use small clusters of non-overlapping potentials as model systems and study both the classical and the quantum time delay.

DY 22.52 Wed 17:00 Poster A

Active self-organization of disordered arrangements of orientation preference in cortical networks — •Juan Daniel Florez Weidinger, Wolfgang Keil, and Fred Wolf — Max Planck Institute for Dynamics and Self-organization and Bernstein Center for Computational Neuroscience, Gottingen,

Many response characteristics of neurons in the brain, including orientation tuning in the primary visual cortex, are believed to arise by dynamical self-organization. The spatial arrangements of tuning properties across the cortex show fundamental interspecies differences. While in primates and carnivores orientation preference form organized orientation maps, in rodents it appears to be randomly distributed. It has been shown that orientation maps in different species realize a common design which can be quantitatively explained by dynamical self-organization. It remains unclear whether a similar approach can also explain rodent functional organization. Here we present an analytically tractable symmetry-based model of the activity-dependent development of orientation selectivity that can describe both types of organization. In the model neurons interact in a distance dependent manner both with isotropic and with orientation selective inhibition and excitation. By symmetry this model has a large set of exact map solutions. Analytically examining their stability, we find that with strong short-range inhibition all map solutions become unstable. We show numerically that in this regime, disordered arrangements become the attractor state of the network.

DY 22.53 Wed 17:00 Poster A

Lattice Boltzmann simulation of thermal convection in a thin film — Markus Abel[3], Luca Biferale[2], Mauro Sbragaglia[2], and •Henning Krüsemann[1] — [1]Universität Potsdam — [2]Università degli Studi di Roma Tor Vergata — [3]Nancy Université

Rayleigh-Bénard convection in thin films has been observed but not yet systematically investigated. Despite being well-studied, the topic still poses open problems, mainly related with scaling at extremely high Rayleigh numbers. Here, we go the opposite direction in considering convection in a very thin film with the aim to study the influence of the forces acting on very small scales, i.e. mainly surfactant forces and disjoining pressure. In detail, we use the shallow water approximation to get a closed set of equations for the thin film evolution. By means of a two-population Lattice-Boltzmann model we explore the dynamics of the system and compare it to a conventional 2D Rayleigh-Bénard system.

DY 23: Quantum Chaos I

Time: Thursday 9:30–11:15 Location: MA 001

DY 23.1 Thu 9:30 MA 001

New Scattering Mechanism in Rough Boundary Nanowires — •Otto Dietz[1,2], Ulrich Kuhl[1], Hans-Jürgen Stöckmann[1,3], Nykolay M Makarov[4], and Felix M Izrailev[4] — [1]FB Physik, Uni Marburg, Germany — [2]Institute of Physics, Humboldt-Universität zu Berlin, Germany — [3]LPMC, Université de Nice Sophia-Antipolis, France — [4]Universidad Autónoma de Puebla, Mexico

Rough boundaries strongly influence the conductance of nanowires. The theoretical description of this influence constitutes an open problem across different fields, from silicon nanowires to graphene nanoribbons.

A recently proposed theory tackles this problem, but is restricted to ensembles of nanowires [1]. To overcome this restriction, we show experimentally that this theory is directly applicable to single nanowires. Now the conductance of a single wire can be calculated analytically from its boundary profile, and vice versa.

This is the first experimental test of the theory. We confirm the surprising prediction of a new scattering mechanism in nanowires. The theory is tested in microwave waveguides with rough walls. Because of the strict analogy between the 2d Schrödinger equation and the Helmholtz equation, the results can be directly applied to electron transport. The advantage of microwave techniques is that - in contrast to real nanowires - the boundary roughness is both known and controllable.

[1] M. Rendón et. al. Phys. Rev. B 75, 205404 (2007)

DY 23.2 Thu 9:45 MA 001

Complex paths for regular-to-chaotic tunneling rates — Arnd Bäcker[1,2], Roland Ketzmerick[1,2], Steffen Löck[1], •Normann Mertig[1,2], and Akira Shudo[3,2] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden — [2]MPI für Physik komplexer Systeme, 01187 Dresden — [3]Department of Physics, Tokyo Metropolitan University, Minami-Osawa, Hachioji, Tokyo 192-0397, Japan

In generic Hamiltonian systems tori of regular motion are dynamically separated from regions of chaotic motion in phase space. Quantum mechanically these phase-space regions are coupled by dynamical tunneling. Based on complex paths, we present a semiclassical prediction of dynamical tunneling rates from regular tori to the chaotic region. This prediction is in excellent agreement with numerically determined tunneling rates of the standard map.

DY 23.3 Thu 10:00 MA 001

Weak (anti-)localization of Bose-Einstein condensates in two-dimensional chaotic cavities — •Timo Hartmann[1], Josef Michl[1], Juan Diego Urbina[1], Cyril Petitjean[2], Thomas Wellens[3], Klaus Richter[1], and Peter Schlagheck[4] — [1]University of Regensburg, Germany — [2]SPSMS-INAC-CEA, Grenoble, France — [3]University of Freiburg, Germany — [4]Université de Liège, Belgium

The possibility to create arbitrarily shaped confinement potentials for cold atoms [1] makes it feasible to study coherent transport of Bose-Einstein condensates through various mesoscopic structures. Previous theoretical studies have focused on the question how coherent backscattering in disordered potentials is modified by the presence of the atom-atom interaction [2]. We now study the analogous scenario of weak localization in ballistic billiard geometries which exhibit chaotic classical dynamics. To this end we investigate the quasi-stationary propagation of a condensate through such structures within the mean-field approximation. The transmission is studied as a function of an artifical magnetic gauge field [3] and of the nonlinearity within the Gross-Pitaevskii equation. Numerical simulations reveal a (partial) inversion of the weak-localization signature with increasing nonlinearity. This effect is analyzed using a diagrammatic perturbation theory based on semiclassical methods.

[1] K. Henderson et al., New J. Phys. **11**, 043030(2009)
[2] M. Hartung et al., Phys. Rev. Lett. **101**, 020603 (2008)
[3] J. Dalibard et al., Rev. Mod. Phys. Colloquium, accepted (2011)

DY 23.4 Thu 10:15 MA 001

Fractal Weyl Law in Systems with a Mixed Phase Space? — Arnd Bäcker[1,2], Roland Ketzmerick[1,2], •Martin Körber[1], and Matthias Michler[1] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany — [2]MPI für Physik komplexer Systeme, 01187 Dresden, Germany

A characteristic feature of open systems is the escape of classical orbits and the decay of quantum states. In ergodic systems the number of long-lived states obeys a fractal Weyl law, where the exponent is associated to the fractal dimension of the repeller. In generic Hamiltonian systems with a mixed phase space, where regular and chaotic motion coexist, the structure of the repeller and its quantum implications are open questions.

In such systems the transport in the chaotic sea is governed by the hierarchy of partial barriers. We design a controllable model system which captures this property. Classically, we analyze the impact on the repeller. Quantum mechanically, we investigate the interplay between the location of eigenstates in the hierarchy and their decay rates in order to clarify the impact on the fractal Weyl law.

DY 23.5 Thu 10:30 MA 001

The semiclassical many body density of states: Progress in the treatment of the smooth part — •Quirin Hummel, Juan Diego Urbina, Jack Kuipers, and Klaus Richter — Universität Regensburg, Germany

For single particle billiard systems, the smooth part of the density of states (DOS) in a semiclassical approximation is known as the Weyl expansion. We study a corresponding expansion for the smooth part of the many body DOS in systems of identical particles. We show that the treatment of exchange symmetry already has a strong effect. As an extension we present progress in including additional effects like physical boundaries. The possibility of including short range interactions among particles is discussed.

DY 23.6 Thu 10:45 MA 001

Resummation of the spectral determinant: the interpretation in terms of orbits — •Daniel Waltner[1], Gregor Tanner[2], and Klaus Richter[1] — [1]Institut I - Theoretische Physik, Universität Regensburg, Universitätsstraße 31, D-93053 Regensburg — [2]School of Mathematical Sciences, University of Nottingham, University Park, Nottingham, NG7 2RD, UK

Calculating spectra based on semiclassical expressions with periodic-orbit sums faces divergence problems in chaotic systems: The number of orbits and thus also the contributions increase exponentially with their length. Based on unitarity, expressions containing finite sums over orbits could be derived for the spectral determinant. However, the underlying orbit correlations that could justify such a resummation procedure remained unclear in this context. Here we want to explain the pseudo-orbit correlations leading to finite pseudo-orbit sums considering graphs with chaotic dynamics.

DY 23.7 Thu 11:00 MA 001

Eigenmodes in the long-time behavior of a coupled spin system measured with NMR — •Benno Meier, Jonas Kohlrautz, and Jürgen Haase — University of Leipzig, Faculty of Physics and Earth Science, Linnéstrasse 5, 04103 Leipzig, Germany

The many body quantum dynamics of coupled spins $I = 1/2$ on an otherwise isolated cubic lattice are studied with nuclear magnetic resonance (NMR). By measuring the free induction decay (FID) of ^{19}F spins in CaF_2 across six orders of magnitude, unique insight into its long-time behavior is obtained. While the recently reported experimental evidence for universal long-time behavior of the form of an exponentially decaying cosine is confirmed experimentally for FID and solid echo experiments, it is possible for the first time to extract a second universal decay mode from the FIDs long-time behavior with comparable frequency but twice as fast a decay rate. The observed response is in agreement with recently published theoretical works and further supports the notion of eigenvalues in chaotic many-body quantum systems.

DY 24: Quantum Chaos II

Time: Thursday 11:30–13:15 Location: MA 001

DY 24.1 Thu 11:30 MA 001

Localization of modes in a dielectric square resonator — •Stefan Bittner[1], Barbara Dietz[1], Jochen Isensee[1], Maksim Miski-Oglu[1], Achim Richter[1,2], and Christopher Ripp[1] — [1]Institut für Kernphysik Darmstadt — [2]ECT* Trento

The correspondence between ray and wave dynamics in dielectric cavities is of high interest due to their applications as microlasers or sensors, and they are used to study the signatures of chaos in open wave-dynamical systems. We present microwave experiments with a dielectric square resonator made of alumina. The frequency spectrum and field distributions were measured and analyzed. Unlike the closed square cavity, the dielectric square resonator is not an integrable system. The field distributions, however, show scarlike patterns and are localised on families of certain classical trajectories. We use a simple model based on the classical ray-dynamics to describe them and obtain good agreement for almost all modes. The work presented in this talk was supported by the DFG within SFB 634.

DY 24.2 Thu 11:45 MA 001

Periodically driven microwave systems - theory and experimental realization — •Stefan Gehler[1], Ulrich Kuhl[1,2], Hans-Jürgen Stöckmann[1], and Timur Tudorovskiy[3] — [1]Fachbereich Physik, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]LPMC, CNRS UMR 6622, Université de Nice Sophia-Antipolis, 06108 Nice, France — [3]Radboud Universiteit, IMM, Heyendaalsweg 135, 6525AJ Nijmegen, Netherlands

A theoretical description and an experimental realization of a periodically perturbed (Floquet) microwave system will be presented. In previous works perturbations of cavities by stationary antennas had been theoretically studied [1] and experimentally verified [2].

This work has now been extended to antennas with a time dependent coupling between antenna and cavity. For an isolated single perturbed resonance the description showed up to be similar to the description of a resonant circuit with a time dependent capacitance. For the experimental realization we developed a resonator with a small inductivity and resistance. Using a varicap as a capacitor the resonance frequency can be changed periodically. A microwave field was driven with a frequency close to the resonator resonance frequency leading to complicated sideband structures. The different obtained sideband structures could be explained perfectly well by the present theory.

[1] T. Tudorovskiy, R. Höhmann, U. Kuhl, and H.-J. Stöckmann, J. Phys. A 41, 275101, 2008.
[2] T. Tudorovskiy, U. Kuhl, and H.-J. Stöckmann, J. Phys. A 44, 135101 (2011).

DY 24.3 Thu 12:00 MA 001

Emission directionality switching for chaotic dielectric cavities — Alexander Eberspächer[1], Jeong-Bo Shim[1], •Jan Wiersig[1], Hui Cao[2], Brandon Redding[2], Qinghai Song[3], and Li Ge[4] — [1]Institut für Theoretische Physik, Otto-von-Guericke-Universität Magdeburg — [2]Department of Applied Physics, Yale University — [3]Harbin Institute of Technology — [4]Princton University

The far-field emission directionality for ultra-small dielectric microcavities is discussed. For deformed microcavity systems, we found that tiny changes in boundary deformations—much smaller than the wavelength—can have drastic effects on the emission directionality of individual modes. Even though one expects that this change cannot be resolved by the optical modes, the far-field can switch directionality. We characterise the emission in terms of tunneling and demonstrate that the changes in boundary deformation induce considerable differences in the dynamical status of the systems under investigation. Then, the relation of dynamical status and emission will be discussed.

DY 24.4 Thu 12:15 MA 001

Spectral properties of rectangular microwave Dirac billiard — •Maksym Miski-Oglu[1], Stefan Bittner[1], Barbara Dietz[1], and Achim Richter[2] — [1]Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany — [2]ECT*, Villa Tambosi, I-38123 Villazzano (Trento), Italy

A spectrum of a superconducting flat microwave Dirac billiard has been measured. The microwave billiard is filled with metallic cylinders which form a photonic crystal with a triangular lattice. In the vicinity of a certain frequency, called the Dirac frequency, the dispersion relation for electromagnetic waves in a photonic crystal is similar to that of a relativistic massless fermion and is described by the Dirac equation. The measurement with a superconducting Dirac billiard allows to obtain experimentally the complete spectrum of eigenvalues and to investigate therewith the level statistics of the corresponding relativistic Dirac billiard. Furthermore the length spectrum of the classical periodic orbits has been extracted from the spectrum of eigenvalues and compared to semiclassical predictions.

This work has been supported within the DFG grant SFB634.

DY 24.5 Thu 12:30 MA 001

From chaotic phase space to structured far fields: A ray study of optical microcavities — •Daniel Kotik and Martina Hentschel — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 83, 01187 Dresden

Optical microcavities have received continuous interest both as model systems for quantum chaos in open systems and as promising nanophotonic devices. The openness of the system originates from the violation of total internal reflection at the dielectric boundary for rays with an angle of incidence smaller than the critical angle. These rays leave the cavity and contribute to the far-field pattern of the microresonator, a property that crucially determines the application potential of the device. There exists an intimate relation between the resonator's unstable manifold and its emission properties that has been known now for some time. Here we present a systematic study on how the far field depends on the details of the ray simulations (choice of initial conditions, number of reflections/trajectory length considered) and on the resonator parameters (geometry, refractive index). Our objective is to investigate under what conditions the far field possesses the same invariant properties as the unstable manifold and to establish the corresponding optimal settings for reliable ray simulations.

DY 24.6 Thu 12:45 MA 001

Varying boundary conditions for dielectric microcavities — •Jörg Götte and Martina Hentschel — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

Circle and semicircle billiards with mixed (Robin) boundary conditions, for which the mixing parameter varies along the boundaries, are singular, if the boundary contains a D point, at which the boundary condition is purely Dirichlet. The spectrum of the Laplace operator for such a billiard is no longer discrete and the energy levels form a continuous spectrum.

A versatile physical realisation to test the predictions of dynamical billiards are dielectric microvavities, and it is possible to design microcavities with varying boundary conditions by embedding a microresonator within a gradient index medium. However, the boundary condition for such a system are dielectric rather than mixed, and it is therefore interesting to see, if similar predictions can be made for an open, dielectric system, for which the exterior of the cavity has to be taken into account. In our work we determine the spectrum of energy levels of a dielectric microcavity with varying boundary conditions and test the system for integrability.

DY 24.7 Thu 13:00 MA 001

Complex dynamics in two-electron quantum dots — •Sebastian Schröter[1], Paul-Antoine Hervieux[2], Giovanni Manfredi[2], Johannes Eiglsperger[3], Moritz Schönwetter[1,4], and Javier Madroñero[1] — [1]TU München — [2]CNRS, IPCMS Strasbourg — [3]Universität Regensburg — [4]MPI PKS, Dresden

To characterise the degree of chaoticity in a quantum system a variety of measures have been established in the literature. A detailed analysis of various spectral properties combined with investigations of the classical analogue and semiclassical properties of a planar anharmonic two-electron quantum dot enables us to classify this system in the regime of weak quantum chaos. The core of our quantum analysis is an *ab initio* approach for planar two-electron quantum dots including full Coulomb interaction. The quantum dot is approximated by an harmonic potential with an additional quartic perturbation introducing irregularity in the system. Via the strength of the quartic potential the transition between regular and choatic dynamics can be tuned. Our model is experimentally accessible and impacts on relevant properties

of coherence in many-body systems [1] can be addressed within our *ab initio* approach.
[1] G. Manfredi, P.-A. Hervieux, New J. Phys. **11** (2009), 013050. – Phys. Rev. Lett. **100** (2008), 050405. – Phys. Rev. Lett. **97** (2006), 190404.

DY 25: Brownian Motion and Transport

Time: Thursday 9:30–13:30 Location: MA 004

Invited Talk DY 25.1 Thu 9:30 MA 004
Through mountains high and valleys low: Ultracold atoms in random potentials. — •Cord Müller — Centre for Quantum Technologies, National University of Singapore

Disorder and interaction are major challenges when it comes to understanding the transport properties of quantum matter. Experiments with ultracold atoms in optical speckle potentials have reached major milestones in the past few years: from 1D Anderson localization in 2008 to 3D localisation of both fermionic and bosonic matter in 2011. I will review these recent achievements in the light of our current theoretical understanding of quantum transport in random media. Perhaps more importantly, I will discuss open questions to be addressed in the future.

DY 25.2 Thu 10:00 MA 004
Nonlinear electrocatalytic microswimmers — •Benedikt Sabass and Udo Seifert — II Institut für Theoretische Physik, Universität Stuttgart

A small, bimetallic particle in hydrogen peroxide solution can propel itself by means of electrocatalytic surface processes. Due to the two different redox potentials, it constitutes a "short-circuited battery". An electric current passes through the particle. The compensating diffusive flux of cations in the solution around the particle drives it forward. We aim towards a theoretical understanding of this far-from-equilibrium swimming mechanism. A simplified, analytically tractable model is presented and the predictions from this model are compared with published experimental findings. We conclude with a brief discussion of generic principles which should be considered when an efficient use of these swimmers is envisaged.

DY 25.3 Thu 10:15 MA 004
Biased and flow driven Brownian motion in periodic channels — •Steffen Martens[1], Arthur Straube[1], Gerhard Schmid[2], Lutz Schimansky-Geier[1], and Peter Hänggi[2] — [1]Humboldt-University Berlin, Department of Physics, Newtonstr. 15, 12489 Berlin, Germany — [2]University Augsburg, Department of Physics, Universitaetsstr. 1, 86135 Augsburg, Germany

We investigate the role of the hydrodynamic flow field on the transport of a Brownian particle in a two-dimensional channel structure exhibiting smoothly varying periodic channel width. In particular, we will present an extension of the so-called Fick-Jacobs approximation [Zwanzig 1992] in order to describe the transport of point-size Brownian particles under the influence of an external force field $V(\mathbf{q})$ as well as an applied flow field $\mathbf{u}(\mathbf{q}, t)$. This is achieved by means of an asymptotic analysis [Martens et al., *Phys. Rev. E* 2011, Martens et al., *Chaos* 2011] to the components of the flow field and to stationary probability density for the particle's position within the channel. We demonstrate how the problem of biased Brownian dynamics in a confined 2D geometry can be reduced to the case of Brownian motion in an effective periodic one-dimensional potential $\Psi(x)$ which takes the external bias, the change of the local channel width, and the flow velocity component in longitudinal direction into account. The influence of the external bias and the pressure drop on the transport quantities like the averaged velocity and the effective diffusion coefficient are studied in detail. The analytic findings are confirmed by numerical simulations of the particle dynamics in a reflection symmetric sinusoidal channel.

DY 25.4 Thu 10:30 MA 004
One-dimensional transport and control in an interacting colloidal system — •Robert Gernert and Sabine H.L. Klapp — Institut für theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We consider a non-equilibrium system of interacting colloids driven by a constant force through a periodic, symmetric „washboard“ potential[1]. As a framework for solving the overdamped equation of motion for the time-dependent density profile, we employ the Dynamical Density Functional Theory (DDFT), where the microscopic particle interactions enter via a free energy functional.

Transport properties such as density profiles, mean-squared displacement[2] and the diffusion coefficient are investigated in dependence of the interaction. In particular, we investigate the impact of interactions on the formation of plateaus in the mean-squared displacement and on the so-called „giant diffusion effect“. Furthermore a feedback control is presented allowing the transport of particles in a package.

Our study shows that the DDFT is capable of describing cage effects as well as motion under driving forces and the impact of feedback control[3].

[1] Lichtner K. and Klapp S.H.L., *EPL* **92** (2010) 40007
[2] Reimann P., Van den Broeck C., Linke H., Hänggi P., Rubi J.M. and Pérez-Madrid A., *Phys. Rev. Lett.* **87** (2001) 010602
[3] Gernert R., Lichtner K., Schirok D. and Klapp S.H.L., in preparation

DY 25.5 Thu 10:45 MA 004
Non-equilibrium effects on granular Brownian motors — •Johannes Blaschke and Jürgen Vollmer — Max Planck Institute for Dynamics and Self Organization, Göttingen, Germany

It has been shown that an appropriately-shaped object, immersed in a Maxwellian gas and restricted to move only in one direction, released from rest will settle away from its point of release as it equilibrates with the gas.

When making the collisions between gas particles and motor inelastic, the device surprisingly acquires a finite steady state velocity. While this has been called a "Granular Brownian Motor", realistic granular gasses have finite particle-particle restitution coefficients leading to constant dissipation within the gas. As a consequence energy needs to be injected into the gas to keep it from freezing. This results in a system which is inherently not in equilibrium. Furthermore, energy generally cannot be injected homogeneously and instead is frequently injected at the walls, manifesting in a non-isotropic particle velocity distribution. This ultimately results in a particle velocity distribution that is both non-Maxwellian and appears as squeezed.

We have examined the motion of a Brownian motor in gases with realistic non-Maxwellian and squeezed particle velocity distribution.

DY 25.6 Thu 11:00 MA 004
Active Brownian Particles with Active Fluctuations — •Pawel Romanczuk[1], Robert Grossmann[2], and Lutz Schimansky-Geier[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden — [2]Institut für Physik, Humboldt Universität zu Berlin, 12489 Berlin

We study the effect of different types of noise on the dynamics of self-propelled agents with variable speed (active Brownian particles). We distinguish between passive and active fluctuations. Passive fluctuations are considered independent of the direction of particle's motion (e.g., thermal fluctuations). In contrast, active ones are assumed to be intrinsically connected with the propulsion mechanism of the agent and, as a result, correlated with its time-dependent orientation. We calculate the stationary speed and velocity probability density functions of non-interacting active Brownian particles in the presence of both fluctuation types and discuss the generic signature of active fluctuations [1]. Furthermore, we discuss swarming of active Brownian particles interacting via a velocity-alignment force [2]. We show, based on the results of a corresponding mean-field theory, how the type of fluctuations has a strong impact on the onset and stability of collective motion.

[1] P. Romanczuk and L. Schimansky-Geier, *Phys Rev Lett*, **106**, 230601 (2011)
[2] P. Romanczuk and L. Schimansky-Geier, *Ecol Compl*, in press, doi:10.1016/j.ecocom.2011.07.008 (2011)

15 min. break

DY 25.7 Thu 11:30 MA 004

Entropic Splitter: Particle Separation by entropic rectification — •Gerhard Schmid[1], David Reguera[2], Antoni Luque[2], Sekhar Burada[3], Miguel Rubi[2], and Peter Hanggi[1] — [1]University of Augsburg, Germany — [2]Universitat de Barcelona, Spain — [3]MPIPKS Dresden, Germany

Diffusive transport of particles or, more generally, small objects, is a ubiquitous feature of physical and chemical reaction systems. In configurations containing confining walls or constrictions, transport is controlled both by the fluctuation statistics of the jittering objects and the phase space available to their dynamics. In the talk I will report on recent advances in the theoretical and numerical investigation of stochastic transport occurring in geometries of varying cross sections.

In nanopores lacking mirror symmetry about a vertical axis rectification favoring transport in one pore direction occurs [1]. The combined action of a time-dependent driving force and this Entropic Rectification can be utilized for particle separation with respect to the particle size [2]. The mechanisms turned out to be very efficient and can be controlled by tuning the geometrical parameters of the pore leading to different velocities and directions of the particles.

[1] G. Schmid, P.S. Burada, P. Talkner, and P. Hänggi, Adv. Solid State Phys. 48, 317 (2009).
[2] D. Reguera, A. Luque, P.S. Burada, G. Schmid, J. M. Rubi, and P. Hänggi, to appear in Phys. Rev. Lett. (2012).

DY 25.8 Thu 11:45 MA 004

Ratchet (re)loaded — •Edward Goldobin[1], Martin Knufinke[1], Dieter Koelle[1], Reinhold Kleiner[1], Konstantin Il'in[2], and Michael Siegel[2] — [1]Physikalisches Institut and Center for Collective Quantum Phenomena in LISA$^+$, University of Tübingen, 72076 Tübingen, Germany — [2]Institut für Mikro- und Nanoelektronische Systeme, Karlsruhe Institute of Technology, 76187 Karlsruhe, Germany

We investigate experimentally a deterministic underdamped Josephson vortex ratchet – a fluxon-particle moving along a Josephson junction in an asymmetric periodic potential. By applying a sinusoidal driving current one can compel the vortex to move in a certain direction, producing an average dc voltage across the junction. Being in such a rectification regime we also load the ratchet, i.e., apply an additional dc bias current $I_{\rm dc}$ (counterforce) which tilts the potential so that the fluxon climbs uphill due to the ratchet effect. The value of the bias current at which the fluxon stops climbing up defines the strength of the ratchet effect and is determined experimentally. This allows us to estimate the loading capability of the ratchet, the output power and efficiency. For the quasi-static regime we present a simple model which delivers simple analytic expressions for the above mentioned figures of merit. [1]

[1] M. Knufinke et al., arXiv:1109.6507

DY 25.9 Thu 12:00 MA 004

Thermodynamics, fluctuation relations and transport in presence of state-dependent diffusion — •Ronald Benjamin — Institut fuer Theoretische Physik II, Universitaet Duesseldorf, D-40225 Duesseldorf, Germany

It is well known that inhomogeneous temperature or state-dependent diffusion can induce transport of a Brownian particle in one direction. In the presence of an external load the system can work as a heat engine or a refrigerator. We discuss the transport coherence and efficiency of this system, otherwise known as the Buettiker-Landauer motor. A recently derived fluctuation theorem for heat engines is also tested by applying it to this system.

DY 25.10 Thu 12:15 MA 004

Directed Transport of Confined Brownian Particles with Torque — •Paul Radtke and Lutz Schimansky-Geier — Institute of Physics, Humboldt University of Berlin, Germany

We investigate the influence of an external magnetic field (torque) on the motion of Brownian particles confined in a channel geometry with varying width. Furthermore, the particles are driven by random fluctuations modeled by the Ornstein-Uhlenbeck process (OUP) with given correlation time τ_c. The latter is implemented as both as thermal and nonthermal process.

In contrast to the thermal OUP for the nonthermal process directed transport emerges, our setup now realizes a ratchet mechanism: Due to the assumed thermodynamic nonequilibrium situation random fluctuations are rectified. The transport quantities of the system are studied in detail with respect to the correlation time, the torque and the channel geometry. Eventually, the mechanism of the symmetry breaking is elucidated.

DY 25.11 Thu 12:30 MA 004

Microrheological Characterization of Acrylic Thickener Solutions — •Anne Kowalczyk and Norbert Willenbacher — Karlsruhe Institute of Technology (KIT), Institute of Mechanical Process Engineering and Mechanics, Gotthard-Franz-Str.3, 76128 Karlsruhe, Germany

The heterogeneous microstructure of three different acrylic thickeners with similar chemical composition but different molecular architecture has been characterized using 2D and 3D multi particle tracking (MPT). Thermal fluctuations of about 100 tracer particles are recorded at a time. We present a customized treatment of so-called tracing errors which occur in 2D tracking experiments which allows us to get physically meaningful results from statistical trajectory analysis for inhomogeneous fluids. We could show that tracer particles are homogeneously distributed and all show the same mobility for the thickener Viscalex HV30. For Sterocoll D the distribution of tracer particles is inhomogeneous, certain areas are not accessible, presumably due to a higher crosslink density, but all tracers exhibit similar mobility. Carbopol solutions show the highest degree of inhomogeneity, a substantial fraction of volume is inaccessible and in addition tracer mobility varies drastically in the remaining portion of the solutions, a fraction of particles is trapped in an elastic, gel-like environment, others can diffuse freely.

DY 25.12 Thu 12:45 MA 004

Directional motion and anomalous diffusion of particles in viscosity landscapes — •Alexei Krekhov, Markus Burgis, and Walter Zimmermann — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

Anomalous diffusion of Brownian particles in inhomogeneous viscosity landscapes is analyzed in the framework of a Langevin equation and a complementary Fokker-Planck equation. In the case of an ensemble of particles starting at a spatial minimum (maximum) of the viscous damping, we find subdiffusive (superdiffusive) motion. Superdiffusion also occurs in the case of a monotonically varying viscosity profile. External forces cause a particle drift in viscous media. We find that an interplay between particle drift and diffusion in the fluid with a spatio-temporal modulated viscosity may lead to an effective particle separation. Different systems for experimental investigations are discussed.

Topical Talk DY 25.13 Thu 13:00 MA 004

Transport beyond Brownian Motion – Persistent correlations — •Thomas Franosch — Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Brownian motion is one of the pillars of statistical physics with applications ranging from astrophysics to biological physics. The theoretical foundation is well understood since Einstein and Smoluchowski introduced a probabilistic interpretation to derive diffusion as a macroscopic law. In modern language, the diffusion propagator follows from the central limit theorem.

Although the mean-square displacement is dominated by the linear increase for long times and finite diffusion constant, persistent correlation underlying the transport may be unraveled by studying the corresponding velocity autocorrelation functions (VACF). I will discuss recent theoretical, simulation, and experimental advances highlighting power-law tails in the VACF which correspond to a colored component in the power spectrum of the force correlator. In particular, I will focus on the effects of hydrodynamic backflow [1,2] and the repeated scattering from frozen obstacles [3,4] as paradigmatic mechanisms to generate persistent correlations.

[1] T. Franosch *et al.*, Nature **478**, 85-88 (2011)
[2] S. Jeney *et al.*, Phys. Rev. Lett. **100**, 240604 (2008)
[3] F. Höfling and T. Franosch, Phys. Rev. Lett. **98**, 140601, (2007)
[4] T. Franosch *et al.*, Chem. Phys. **375**, 530 (2010)

DY 26: Joint focus session: Alternative Energies: Compensation of long- and short-term fluctuations (with DF)

Organization: J. Peinke (Carl von Ossietzky Universität Oldenburg) and M. Diestelhorst (Martin-Luther-Universität Halle-Wittenberg)

Time: Thursday 15:00–18:10 Location: EB 107

Topical Talk DY 26.1 Thu 15:00 EB 107
Wind energy - Characterization and modeling of short-term fluctuations in incoming wind and power output — •Michael Hölling, Matthias Wächter, Allan Morales, Patrick Milan, and Joachim Peinke — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg

One inherent characteristic of turbulent atmospheric wind fields is their correlation in time and space, which results in intermittent behavior of velocity increments on a wide range from very small to very large scales. Wind energy converters work in this highly intermittent environment and transfer these fluctuations to the generator and the power output, respectively. With a significantly increased wind power production in the future, there is a need to better understand the interaction of turbulent wind fields with wind turbines. We present methods to describe and model these intermittent characteristics of atmospheric flows and power output of wind turbines using stochastic analysis. Data from wind tunnel experiments on blade segments with respect to lift forces under turbulent wind conditions show dynamic stall like behavior with an increased maximum lift force shifted to higher angles of attack compared to laminar inflow conditions. In addition an increase in the standard deviation in the acting lift forces is observed, which leads to dynamic changes in loads, that have to be accounted for e.g. in the design process of the wind turbine. Also the power output from wind turbines shows intermittent behavior resulting from the turbulent wind fields. The presented methods can help to describe and predict power fluctuations and to make the machines last longer.

Topical Talk DY 26.2 Thu 15:30 EB 107
Fluktuationen in der Stromerzeugung aus erneuerbarer Energien: Ihre Charakterisierung und Möglichkeiten ihrer Kompensation — •Detlev Heinemann — AG Energiemeteorologie, Institut für Physik, Universität Oldenburg

Die Beitrag der erneuerbaren Energien aus Wind und Solarstrahlung an der deutschen Stromversorgung nähert sich der 20%-Marke. Damit sind erhebliche und nur teilweise vorhersagbare Schwankungen der Erzeugung verbunden und es wird z.B. zunehmend der Bedarf an Systemunterstützung z.B. durch Speicherung diskutiert. Noch wenig bekannt ist, wie weit dieser Speicherbedarf durch Ausnutzung von vorhandenen Ausgleichseffekten und durch eine intelligente Steuerung des Verhaltens der Komponenten im Stromnetz ('Smart Grid') unter Einbeziehung einer präziseren Charakterisierung der Fluktuationen reduziert werden kann.

Der Beitrag charakterisiert - ausgehend von einer Phänomenologie der beobachteten Ereignisse - die für die Energieträger Wind und Solarstrahlung wesentlichen Fluktuationen. Dabei werden die unterschiedlichen zeitlichen und räumlichen Skalen der Fluktuationen betrachtet und ebenfalls räumliche Korrelationen der zeitlichen Schwankungen untersucht. Die Beeinflussung der effektiven Stromerzeugungs-Kapazität aus Wind- und Solarenergie durch diese statistischen Effekte wird diskutiert. Abschliessend werden aktuelle Ansätze eines Ausgleichs dieser Fluktuationen sowohl durch technische Massnahmen als auch durch den Einsatz intelligenter Verfahren vorgestellt.

Topical Talk DY 26.3 Thu 16:00 EB 107
Glasses and glass ceramics as dielectrics for high power capacitors. — •Martin Letz — Schott AG, Mainz, Germany

Temperature stable, reliable and long lasting capacitors are a key component for high power electronics enabling large amount of fluctuating energy sources in the public electricity grid. Since many decades inorganic materials are known as excellent dielectrics. Among these thin foils made from alkaline free special glass are known for their very good homogeneity and excellent surface roughness. Such glass foils can reach dielectric breakdown strengths of 690 kV/mm (measured at 0.025 mm thickness) and more. Due to their excellent thermal stability they can be used for temperatures up to 500 °C as dielectrics in capacitors. A further class of materials are glass ceramics obtained via a true homogeneous glassy phase. Here it is possible to crystallize out ferroelectric phases like BaTiO3 in form of nano crystallites leading to high dielectric constants. Obtained from a true glassy phase such glass ceramics are free of pores and reach dielectric breakdown strengths of 40kV/mm (measured at 0.2 mm thickness). The current development for such glasses and glass ceramics is presented which shows the possibility for obtaining high power capacitors which exceed the energy storage capacity of todays high power capacitor solutions by more than one order of magnitude.

DY 26.4 Thu 16:30 EB 107
The dielectric AC and DC characterisation of composite capacitors for energy storage — •Sebastian Lemm[1], Wolfram Münchgesang[1], Martin Diestelhorst[1], Mandy Zenkner[2], Thomas Grossmann[2], Alexandra Buchsteiner[3], Horst Beige[1], Stefan G. Ebbinghaus[2], and Hartmut S. Leipner[3] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [2]Institut für Chemie, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [3]Interdisziplinäres Zentrum für Materialwissenschaften , Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany

Today, rechargeable batteries are mostly used for energy storage. An alternative to the electrochemical storage process in batteries are capacitors with a high energy density and a long carrier storage time. For the design and development of such capacitors the default dielectric AC characterisation method for capacitors is inadequate because the energy storage process operates under DC conditions. We present a measurement procedure which includes DC and AC characterisation using the example of composite capacitors consisting of barium titanate nanoparticles embedded in a matrix material. Furthermore we show the differences between the measurement methods and the problems of analysing such capacitors.

DY 26.5 Thu 16:50 EB 107
Permittivity, energy density and carrier storage time of film composite capacitors — •Wolfram Münchgesang[1], Sebastian Lemm[1], Martin Diestelhorst[1], Claudia Ehrhardt[2], Jens Glenneberg[3], Alexandra Buchsteiner[3], Horst Beige[1], Stefan G. Ebbinghaus[2], and Hartmut S. Leipner[3] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [2]Institut für Chemie, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [3]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany

Thin film composite capacitors are a possible alternative for batteries as energy storage. Their anticipated advantages are short charging and discharging times, a long life cycle, higher energy density and lower temperature dependency. We tested this predicted behaviour of such film composite capacitors under DC and AC conditions. The thin film composites based on nanoparticles of barium titanate which are embedded in a polymeric organic matrix and surface-modified by surfactants.

Topical Talk DY 26.6 Thu 17:10 EB 107
High Tc Superconducting Energy Storage Systems — •Frank Werfel — Adelwitz Technologiezentrum GmbH (ATZ), Arzberg-Adelwitz, Germany

Electric energy is basic to heat and light our homes, to power our businesses and to transport people and goods. Powerful storage techniques like SMES, Flywheel, Super Capacitor, and Redox - Flow batteries are needed to increase the overall efficiency, stability and quality of electrical grids. High-Tc superconductors (HTS) possess superior physical and technical properties and can contribute in reducing the dissipation and losses in electric machines as motors and generators, in electric grids and transportation. The renewable energy sources as solar, wind energy and biomass will require energy storage systems even more as a key technology. We survey the physics and the technology status of superconducting flywheel energy storage (FESS) and magnetic energy storage systems (SMES) for their potential of large-scale commercialization. We report about a 10 kWh / 250 kW flywheel with magnetic stabilization of the rotor. The progress of HTS conductor science and technological engineering are basic for larger SMES developments. The performance of superconducting storage systems is reviewed and compared. We conclude that a broad range of intensive research and development in energy storage is urgently needed to produce technological options that can allow both climate stabilization and economic development.

Topical Talk DY 26.7 Thu 17:40 EB 107

The transmission of high-power microwaves via dielectric diamond windows: Design, qualification and first steps towards a broadband diamond window in the range of 30GHz to several THz for actual and future fusion devices — •Theo Scherer and Dirk Strauss — Karlsruhe Institute of Technology KIT; D-76021 Karlsruhe

The development of artificial diamond disks fabricated by special RF CVD processes lead to a new generation of dielectric high power millimetre wave windows with extremely low absorption and scattering losses for high power transmission. The quality of diamond as a window material is further given by its well known excellent mechanical properties and extremely high thermal conductivity. The growth process of the diamond disks is based on chemical vapour deposition (CVD) with micro/nano diamond nuclei. The transmission losses of the disk are caused by graphite formation mainly at the surface of the disk but also on the grain boundaries. RAYLEIGH scattering limits the value of loss tangent in bulk. A high quality measurement of the disk surface and bulk properties using spherical and hemispherical resonators is presented for frequencies from 90 up to 170 GHz.

The state of the art windows used in high power electron cyclotron heating and current drive (ECRH&CD) for large fusion devices such as ITER consist of a disk perpendicular to the millimetre wave beam propagation. As reflection have to be kept on a minimal level, the window thickness limits the allowed frequencies to a limited set defined by multiples of lambda/2 in the dielectric matter.

DY 27: Transport and Anomalous Diffusion

Time: Thursday 14:30–17:15 Location: MA 004

Topical Talk DY 27.1 Thu 14:30 MA 004

Single particle trajectories and weak ergodicity breaking in ageing systems — •Ralf Metzler — Inst for Physics & Astronomy, University of Potsdam, Germany — Physics Dept, Tampere University of Technology, Finland

In 1905 Einstein formulated the laws of diffusion, and in 1908 Perrin published his Nobel-prize winning studies determining Avogadro's number from diffusion measurements. With similar, more refined techniques the diffusion behaviour in complex systems such as the motion of tracer particles in living biological cells is nowadays measured with high precision. Often the diffusion turns out to deviate from Einstein's laws. This talk will discuss the basic mechanisms leading to such anomalous diffusion as well as point out its consequences. In particular the unconventional behaviour of non-ergodic, ageing systems will be discussed within the framework of continuous time random walks. Indeed, non-ergodic diffusion in the cytoplasm of living cells as well as in membranes has recently been demonstrated experimentally.

DY 27.2 Thu 15:00 MA 004

Fluctuations of time averages for Langevin dynamics in a binding force field — •Andreas Dechant[1], Eric Lutz[2], David A. Kessler[3], and Eli Barkai[3] — [1]Department of Physics, Universität Augsburg, D-86356 Augsburg, Germany — [2]Department of Physics, Freie Universität Berlin, D-14195 Berlin, Germany — [3]Department of Physics, Institute of Nanotechnology and Advanced Materials, Bar Ilan University, Ramat Gan 52900, Israel

We derive a simple formula for the fluctuations of the time average around the thermal mean for overdamped Brownian motion in a binding potential. Using a backward Fokker-Planck equation, introduced by Szabo et al. in the context of reaction kinetics, we show that for ergodic processes these finite measurement time fluctuations are determined by the Boltzmann measure. For the widely applicable logarithmic potential, ergodicity is broken. We quantify the large non-ergodic fluctuations and show how they are related to a super-aging correlation function.

DY 27.3 Thu 15:15 MA 004

Fractional Brownian ratchets — •Igor Goychuk[1] and Vasyl Kharchenko[1,2] — [1]Institute of Physics, University of Augsburg, Universitätstr. 1, D-86135 Augsburg, Germany — [2]Institute of Applied Physics, 58 Petropavlovskaya str., 40030 Sumy, Ukraine

We study fluctuating tilt Brownian ratchets based on fractional subdiffusion in sticky viscoelastic media characterized by a power law memory kernel [1]. Unlike the normal diffusion case the rectification effect vanishes in the adiabatically slow modulation limit and optimizes in a driving frequency range [2]. It is also shown [3] that anomalous rectification effect is maximal (stochastic resonance effect) at optimal temperature and can exhibit a surprisingly good quality. Moreover, subdiffusive current can flow in the counter-intuitive direction upon a change of temperature or driving frequency. The dependence of anomalous transport on load exhibits a remarkably simple universality.

Support of this work by the DFG, grant GO 2052/1-1 is gratefully acknowledged.

[1] I. Goychuk, Phys. Rev. E **80**, 046125 (2009); Adv. Chem. Phys. **150**, 187–253 (2012); [2] I. Goychuk, Chem. Phys. **375**, 450 (2010); [3] I. Goychuk and V. Kharchenko, arXiv:1111.4833[cond-mat.stat-mech] (2011).

DY 27.4 Thu 15:30 MA 004

The resolution of the entropy production paradox of fractional diffusion equations — •Janett Prehl[1], Karl Heinz Hoffmann[1], and Chris Essex[2] — [1]TU Chemnitz, Institut für Physik, D-09107 Chemnitz, Germany — [2]University of Western Ontario, Departement of Applied Mathematics, London, ON, Canada N6A 5B7

Both, time- and space-fractional diffusion equations can be defined as a one parameter bridging regime going from diffusion equation to wave- or half wave equation. The solutions of these fractional diffusion equations represent superdiffusion processes. Contrary to intuition, the corresponding entropy production rates grow moving from irreversible diffusive to reversible wave-like behavior. This paradox was discovered for the time- and space-fractional diffusion equation and not only for the Shannon entropy but also for its generalized entropy definitions, the Tsallis and the Rényi entropy. For the first time we show a generalized method to resolve this paradoxical behavior for both fractional equations and all introduced entropy definitions.

[1] C. Essex, C. Schulzky, A. Franz, K. H. Hoffmann, *Phys,A* (2000) **284**: 299–309

[2] J. Prehl, C. Essex, K. H. Hoffmann, *Phys.A* (2010) **389**: 215–224

DY 27.5 Thu 15:45 MA 004

Convex Hulls of Levy Walks — •Mirko Lukovic, Stephan Eule, and Theo Geisel — MPI for Dynamics and Self-Organization, Goettingen, Germany

Recently there has been much debate in the scientific community as to whether the observed walk patterns of foraging animals are Lévy-like or not. This is mainly due to the poor accuracy of the statistical methods employed to indentify Lévy behaviour from collected data samples of animal trajectories. There are cases where strong evidence was found for Lévy walks by using an extremely large data set of animal movement (Humphries *et al.* Nature 2010). We propose the use of convex hulls (minimum convex polygon enclosing the recorded points (Majumdar *et al.* 2009)) of the home range of animals as a robust and accurate method to discriminate between different types of foraging animal motions. The method is simple and robust even in the case where data available is sparse and it should be able to determine the degree of how Lévy-like a recorded trajectory is. In addition, we do not need to know in which order the animal visited the registered points.

DY 27.6 Thu 16:00 MA 004

Efficient simulation of Fractional Brownian Motion for several values of the Hurst exponent — •Alexander K. Hartmann[1], Satya N. Majumdar[2], and Alberto Rosso[2] — [1]Institute of

Physics, University of Oldenburg, Germany — [2]LPTMS, Université Paris-Sud, France

We study Fractional Brownian Motion (FBM), i.e., Gaussian processes with zero mean and a correlator of the form $C(t,t') = t^{2H} + (t')^{2H} - |t-t'|^{2H}$, in the presence of an absorbing boundary. The strength of the correlation is described by the *Hurst exponent* H, whereas $H = 0.5$ corresponds to the uncorrelated random walk (diffusion), $H > 0.5$ to positive correlations (superdiffusion) and $H < 0.5$ to anticorrelations (subdiffusion) of the movement. FBM is, e.g., believed to describe the translocation of polymers through pores.

Recently, analytical predictions [1,2] were obtained for the distribution $P(x)$ of walk endpoints x. Standard numerical simulations study FBM via generating (discrete-time) random walks directly. They are, in particular for $H < 0.5$, very demanding, since the success probability of generating a non-absorbed trajectory is very small. Hence, such simulations were restricted to a small number L of discrete steps. Here, using a special Monte Carlo Simulation, long walks up to $L = 10^7$ could be generated for values $H = 1/4$, 4/9, 1/2 and 2/3. The results are compared with the analytical predictions.

[1] A. Zoia, A. Rosso, S. N. Majumdar, Phys. Rev. Lett. **102**, 120602 (2009)

[2] K. J. Wiese, S. N. Majumdar, A. Rosso, arXiv:1011.4807

DY 27.7 Thu 16:15 MA 004

Simulation of colloids in microchannels: channel width effects on diffusion — •Ullrich Siems and Peter Nielaba — Department of Physics, University of Konstanz, 78457 Konstanz, Germany

The results of a Brownian dynamics simulations (BD) of colloidal particles in a two-dimensional microchannel are presented. The particles pair potential is modeled by a repulsive $1/r^3$ potential and a hard core interaction. The diffusion along the channel direction is investigated for various channel widths at a constant interaction strength. For channels, where the mutual passing of particles is forbidden due to the hard core interaction, single-file diffusion has been observed in agreement with former simulations and experiments.

For wider channels a three regime diffusion behavior can be observed: the diffusion is normal in the short-time limit and long-time limit, but sub-diffusive on intermediate time scales. The time evolution of the mean square displacement can be completely characterized by the two transition times and the diffusion coefficients for the short-time and the long-time limit. These parameters were obtained by a fit of a Fermi distribution to the logarithmic coordinates of the time-dependent diffusion coefficient $D(t) =<\Delta x^2> /2t$. The transition times and the long-time diffusion coefficient have an oscillating dependency on the channel width, which can be explained by layering effects.

DY 27.8 Thu 16:30 MA 004

Effective diffusion and subdiffusion in inhomogeneous lattice models — •Federico Camboni — Humboldt University Berlin Germany

We discuss the problem of the evaluation of an effective diffusion coefficient for a particle in a disordered medium with energetic disorder (homogeneous and isotropic in the statistical sense) in arbitrary dimension. We present a formal, general expression for such a diffusion coefficient based on the reduction of the system to an effective resistor-capacitor network, with site-dependent activities playing a role of electric potential. We discuss the effective medium approximation for the diffusivity and its upper and lower Hashin-Shtrikman bounds. We moreover investigate situations under which anomalous diffusion in a random potential model can apprear, and show that there are two and only two corresponding situations, namely the ones corresponding to a generalized trap model and to the percolation case.

DY 27.9 Thu 16:45 MA 004

Space-resolved Dynamics in a Simple Porous Media Model — •Markus Spanner[1], Simon Schnyder[2], Thomas Voigtmann[3], and Thomas Franosch[1] — [1]Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Institut für Theoretische Physik II, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany — [3]Institut für Materialphysik im Weltraum, DLR, 51170 Köln, Germany and Zukunftskolleg, Universität Konstanz, 78457 Konstanz, Germany

The Lorentz model is a simple model for transport in porous materials, where a point-like tracer explores the space between an array of quenched spherical obstacles. It was shown in previous computer simulations, that in the vicinity of the localization transition, the remaining void space becomes fractal, thus transport is drastically hindered and anomalous dynamics emerges. When considering only trajectories on the infinite cluster, sub-diffusive motion $\delta r_\infty^2 \sim t^{2/d_w}$ is found to follow an exponent of $d_w = 4.81$, known as the walk dimension.

Employing further extensive molecular dynamics simulation, both for ballistic and Brownian motion, we investigate the spatio-temporal dynamics of tracer particles in the Lorentz model in terms of the intermediate scattering functions. Covering different time and length scales simultaneously, these functions are sensitive to both the underlying spatial fractal and the anomalous transport.

We compare our simulation results close to the critical density to a mode-coupling approach, and find that certain aspects are surprisingly well predicted.

DY 27.10 Thu 17:00 MA 004

Minimal mean first passage time in a piecewise linear potential landscape — •Vladimir V. Palyulin[1] and Ralf Metzler[2] — [1]Physik Department (T30g), Technical University of Munich, James Franck Strasse, 85747 Garching, Germany — [2]Chair for Theoretical Physics, Inst for Physics & Astronomy, University of Potsdam, 14476 Potsdam-Golm, Germany

How can we minimize the mean first passage time between two points x_1 and x_2, whose energies are E_1 and E_2 ($E_1 > E_2$)? Naively, one might suppose that the solution is a linear potential drop between the two points. However, in our analysis we show that for an energy landscape consisting of two linear parts, a potential barrier with height $E_b > E_1$ leads to a decrease of the mean first passage time. Similar results hold for subdiffusive conditions.

Our a priori surprising findings are obtained analytically and supported by numerical analysis. Several approaches were used, namely, direct numerical solution of fractional Fokker-Planck equation with Gruenwald-Letnikov representation of the fractional derivative, numerical inverse Laplace transform of first passage time density obtained by solution of equation in Laplace space, and Monte Carlo simulation approach.

DY 28: Data Analysis Methods and Modelling of Geophysical Systems

Time: Thursday 15:00–17:45 Location: MA 144

DY 28.1 Thu 15:00 MA 144

Nonlinear detection of paleoclimate-variability transitions possibly related to human evolution — •Jonathan F. Donges[1,2], Reik V. Donner[1], Martin H. Trauth[3], Norbert Marwan[1], Hans Joachim Schellnhuber[1], and Jürgen Kurths[1,2] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Department of Physics, Humboldt University, Berlin, Germany — [3]Department of Earth and Environmental Sciences, University of Potsdam, Potsdam, Germany

Potential paleoclimatic driving mechanisms acting on human evolution present an open problem of cross-disciplinary scientific interest. The analysis of paleoclimate archives encoding the environmental variability in East Africa during the last 5 Ma (million years) has triggered an ongoing debate about possible candidate processes and evolutionary mechanisms. In this work, we apply a novel nonlinear statistical technique, recurrence network analysis, to three distinct marine records of terrigenous dust flux. Our method enables us to identify three epochs with transitions between qualitatively different types of environmental variability in North and East Africa. A reexamination of the available fossil record demonstrates statistically significant coincidences between the detected transition periods and major steps in hominin evolution. This suggests that the observed shifts between more regular and more erratic environmental variability may have acted as a trigger for rapid change in the development of humankind in Africa.

DY 28.2 Thu 15:15 MA 144

Correlations of record events as a test for heavy-tailed distri-

butions — •Jasper Franke, Gregor Wergen, and Joachim Krug — Institut für Theoretische Physik, Universität zu Köln, Germany

A record is an entry in a time series that is larger or smaller than all previous entries.

If the time series consists of independent, identically distributed random variables with a superimposed linear trend, record events are positively (negatively) correlated when the tail of the distribution is heavier (lighter) than exponential. Here we use these correlations to detect heavy-tailed behavior in small sets of independent random variables. The method is based on choosing ordered subsets of the data, adding a linear trend, and estimating the resulting record correlations.

DY 28.3 Thu 15:30 MA 144

Predictability of temperature exceedance events by data-driven and physical-dynamical modeling — •Stefan Siegert and Holger Kantz — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

We present a predictability study of temperature in Hannover, Germany. We issue probabilistic predictions for the event that the value of the temperature exceeds a certain threshold on the next day. The forecast probabilities are generated via two different approaches. In the data-driven approach, an autoregressive model is used to generate the exceedance probability conditional on temperature measurements from the immediate past. In the physical modeling approach, an ensemble of runs generated by an atmospheric circulation model is used. Predictions issued by these two approaches are compared by proper skill scores. A decomposition of the skill scores is used to assess different forecast attributes, namely resolution and reliability. The main conclusion of the study is that the physical modeling approach is superior to the data-driven approach, but only after the model output has been corrected by statistical post-processing.

DY 28.4 Thu 15:45 MA 144

Visibility graphs for testing reversibility of time series — •Jonathan F. Donges[1,2] and Reik V. Donner[1] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Department of Physics, Humboldt University, Berlin, Germany

Reversibility or time reversal symmetry is a fundamental property of time series. Among other applications, it can be harnessed for selecting models that are consistent with experimental time series data. We propose a novel set of statistical tests against reversibility based on visibility graphs constructed from time series as well as on time-directed variants of common graph-theoretical measures like degree and local clustering coefficient. Unlike other tests against reversibility, the technique proposed here has the advantage that it does not require the construction of surrogate time series. We investigate the performance of our statistical tests for time series from paradigmatic model systems with known time reversal properties and compare it to a traditional test against reversibility. Finally, our tests are applied to characterize the temporal structure of electroencephalogram (EEG) time series representing normal and pathological dynamics of the human brain.

DY 28.5 Thu 16:00 MA 144

State and parameter estimation for nonlinear systems — •Jan Schumann-Bischoff, Stefan Luther, and Ulrich Parlitz — Biomedical Physics, Max Planck Institute for Dynamics and Self-Organization, Am Fassberg 17, 37077 Göttingen

We present an efficient method for estimating variables and parameters of a given system of ordinary differential equations by adapting the model output to an observed time series from the (physical) process described by the model. The proposed method [1] is based on (unconstrained) nonlinear optimization exploiting the particular structure of the relevant cost function. For illustrating features and performance of the method simulations are presented using chaotic time series generated by the Colpitts oscillator, the three dimensional Hindmarsh-Rose neuron model and a 9-dimensional extended hyperchaotic Rössler system.

[1] J. Schumann-Bischoff and U. Parlitz, State and parameter estimation using unconstrained optimization, *Phys. Rev. E* 84, 056214 (2011)

DY 28.6 Thu 16:15 MA 144

Signal analysis and classification using ordinal patterns — •Ulrich Parlitz, Sebastian Berg, and Stefan Luther — Biomedical Physics, Max Planck Institute for Dynamics and Self-Organization, Am Fassberg 17, 37077 Göttingen

Ordinal patterns [1-5] describe the relations within short segments of a given time series. They are easy to compute and robust against noise. For this reason ordinal patterns have been used in a wide range of applications like detection of determinism in noisy time series [4], estimation of transfer entropy in epilepsy [3], or complexity analysis of time series [1,2]. In this contribution we shall present and discuss applications of ordinal pattern statistics for synchronization analysis, forecasting and signal classification. In particular very promising applications to ECG data [5] will be discussed which show that symbolic dynamics based on ordinal patterns provides a powerful tool for coping with data from life sciences.

[1] J.M. Amigo, Permutation Complexity in Dynamical Systems, Springer Series in Synergetics, Springer-Verlag Berlin Heidelberg (2010).
[2] C. Bandt and B. Pompe, Phys. Rev. Lett. 88, 174102 (2002).
[3] M. Staniek and K. Lehnertz, Phys. Rev. Lett. 100, 158101 (2008).
[4] J.M. Amigo et al., EPL 79 50001 (2007); EPL 83, 60005 (2008).
[5] U. Parlitz et al., "Classifying cardiac biosignals using ordinal pattern statistics and symbolic dynamics", to appear in: Computers in Biology and Medicine, available online 20 April 2011, doi:10.1016/j.compbiomed.2011.03.017

DY 28.7 Thu 16:30 MA 144

On bi- and multivariate extensions of recurrence network analysis — Jan H. Feldhoff[1,2], •Reik V. Donner[1], Jonathan F. Donges[1,2], Norbert Marwan[1], and Jürgen Kurths[1,2] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Department of Physics, Humboldt University of Berlin, Germany

Recurrence plots (RPs) obtained from time series are known to contain all essential information on the dynamical characteristics of underlying dynamical systems. Recently, it has been suggested to reinterpret the RP as the connectivity matrix of a complex network associated with the time series under study. Statistical measures characterizing the topology of such recurrence networks on both local and global scale have already demonstrated their great potential for detecting changes in the underlying dynamics as reflected in the geometry of the corresponding attractor in phase space.

Here, we introduce two possible extensions of the recurrence network approach for studying two or more potentially coupled dynamical systems. Specifically, the established concepts of cross- and joint RPs, as well as the recently introduced graph-theoretic framework for describing the properties of interacting networks are utilized for deriving a corresponding complex network representation. We discuss the interpretation of both approaches in terms of the associated phase space properties and provide some examples highlighting their performance for studying interacting complex systems.

DY 28.8 Thu 16:45 MA 144

Similarity measures for irregularly sampled time series — •Kira Rehfeld[1,2], Norbert Marwan[1], Jobst Heitzig[1], and Jürgen Kurths[1,2] — [1]Potsdam Institute for Climate Impact Research, Potsdam, Germanyesearch, Potsdam, Germany — [2]Department of Physics, Humboldt University Berlin, Berlin, Germany

Automated and joint analysis and inter-comparison of palaeoclimatological time series from proxy archives, e.g. stalagmites, ice and sediment cores, is of much interest in the study of past climate and its changes. Due to heterogeneous archive properties, reconstructed observation times are not spaced at regular intervals. This introduces an additional, substantial, error source when applying standard linear and nonlinear measures, as necessary interpolation introduces bias, especially for high-frequency signal components. Using kernel-based approaches, we circumvent the need for interpolation and use the information contained in the time series at the different time scales directly. In benchmark tests we compare results for kernel-based Pearson correlation and mutual information to estimates obtained from standard interpolation-based methods. We illustrate robustness, reliability and superiority of the new methods using synthetic time series of known inter-sampling time distributions similar to those found in reality and show that the results we obtain from palaeo records show the same characteristics. To illustrate the capability of our approach we construct, analyze and interpret small complex networks from palaeo records of Asian Monsoon variability.

DY 28.9 Thu 17:00 MA 144

Early warning signals: a generalised modelling approach — •Steven Lade[1] and Thilo Gross[1,2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Engineering Mathematics, University Of Bristol, United Kingdom

Critical transitions, here defined as sudden and difficult to reverse changes of state that are often associated with bifurcations, occur in many systems in nature and society such as ecology, physiology, climate, and economies. Given the often catastrophic nature of these transitions, some warning of these transitions is highly desirable. Over the last decade a number of such early warning signals have been proposed based on simple analyses of time series data, for example an increasing variance or increasing autocorrelation.

These methods, however, can be limited by the amount of data they require. In this talk I will propose a new method that significantly reduces the amount of data required. It is based on combining multiple types of time series data with system-specific structural knowledge through the framework of a generalised model. I apply the method to two ecological examples, including the simulated collapse of a fishery.

Topical Talk DY 28.10 Thu 17:15 MA 144

Sensitivity and out-of-sample error in data assimilation — •Jochen Bröcker — Max-Planck-Institut für Physik komplexer Systeme

“Data Assimilation” is one of many names for the following problem: Given a history of observations as well as a dynamical model, find trajectories which are, on the one hand, consistent with the model, and on the other hand, consistent with the observations. Attaining both objectives at the same time is essentially never possible (nor in fact desired) in reality, since our models are invariably simplifications. Any data assimilation algorithm should therefore allow for deviations from the proposed model equations as well as from the observations. How we might trade off between these two is the subject of this talk. It is shown how we can still find “good” trajectories, where the measure of goodness obviously cannot be just the deviation from the observations. Rather, a measure similar to the out-of-sample error from statistical learning is considered. The connection between the out-of-sample error and the sensitivity is elucidated, including some numerical examples.

Reference:

J.B., Ivan G. Szendro, Sensitivity and out–of–sample error in continuous time data assimilation, *Quarterly Journal of the Royal Meteorological Society*, 2011.

DY 29: Posters II

Time: Thursday 17:00–19:00 Location: Poster A

DY 29.1 Thu 17:00 Poster A

Bound states in bent waveguides — Stefan Bittner[1], Barbara Dietz[1], Jochen Isensee[1], Maksim Miski-Oglu[1], Achim Richter[1,2], and •Christopher Ripp[1] — [1]Institut für Kernphysik Darmstadt — [2]ECT* Trento

Bound states in quantum wires or open electromagnetic waveguides with curves, bends or bulges have received much interest for several reasons. Firstly, they can modify the transmission properties of such devices, and secondly, their existence is a purely wave-dynamical phenomenon which has no classical analogue. Different geometries and the properties of the bound states of quantum wires and electromagnetic waveguides, which are described by the same Helmholtz equation, have been investigated extensively both theoretically and experimentally. We present microwave experiments with sharply bent waveguides. The interesting feature of such waveguides is that not only one, but arbitrarily many bound states can exist depending on the angle of the bend: new bound states emerge at certain critical angles. Several waveguides with bend angles close to these critical ones were investigated. The resonance frequencies and field distributions were measured experimentally and compared to theoretical calculations. Good agreement was found and the values for the critical angles were confirmed. Furthermore, the effect of the finite length of the waveguide was investigated. The work presented on this poster was supported by the DFG within SFB 634.

DY 29.2 Thu 17:00 Poster A

Periodically driven microwave systems - theory and experimental realization — •Stefan Gehler[1], Ulrich Kuhl[1,2], Hans-Jürgen Stöckmann[1], and Timur Tudorovskiy[3] — [1]Fachbereich Physik, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]LPMC, CNRS UMR 6622, Université de Nice Sophia-Antipolis, 06108 Nice, France — [3]Radboud Universiteit, IMM, Heyendaalsweg 135, 6525AJ Nijmegen, Netherlands

A theoretical description and an experimental realization of a periodically perturbed (Floquet) microwave system will be presented. In previous works perturbations of cavities by stationary antennas had been theoretically studied [1] and experimentally verified [2].

This work has now been extended to antennas with a time dependent coupling between antenna and cavity. For an isolated single perturbed resonance the description showed up to be similar to the description of a resonant circuit with a time dependent capacitance. For the experimental realization we developed a resonator with a small inductivity and resistance. Using a varicap as a capacitor the resonance frequency can be changed periodically. A microwave field was driven with a frequency close to the resonator resonance frequency leading to complicated sideband structures. The different obtained sideband structures could be explained perfectly well by the present theory.

[1] T. Tudorovskiy, R. Höhmann, U. Kuhl, and H.-J. Stöckmann, J. Phys. A 41, 275101, 2008.
[2] T. Tudorovskiy, U. Kuhl, and H.-J. Stöckmann, J. Phys. A 44, 135101 (2011).

DY 29.3 Thu 17:00 Poster A

Experimental Test of a Trace Formula for Chaotic Dielectric Resonators — Stefan Bittner[1], Barbara Dietz[1], •Jochen Isensee[1], Maksim Miski-Oglu[1], Achim Richter[1,2], and Christopher Ripp[1] — [1]Institut für Kernphysik Darmstadt — [2]ECT* Trento

Due to their applicability, e.g., as microlasers and or in integrated optics dielectric resonators have drawn a lot of attention in recent years. The correspondence between ray and wave dynamics is of particular interest to understand their properties and is provided by so-called trace formulas. We present an experimental test of a trace formula proposed by Bogomolny et al. in Ref. [1] for dielectric resonators with chaotic classical dynamics. The frequency spectra of two dielectric stadium resonators made of Teflon were measured in a microwave experiment. About 5% of the total number of resonances could be extracted from the measured frequency spectra. The corresponding length spectra were compared to semiclassical ones obtained with the help of the trace formula. Good qualitative agreement between the experimental and the semiclassical length spectrum was found. Further investigations with numerically calculated spectra revealed, however, that higher order corrections to the trace formula are needed. This work was supported by the DFG within SFB 634.

[1]: Bogomolny et al., Phys. Rev. E 78, 056202 (2008).

DY 29.4 Thu 17:00 Poster A

Integrable Approximation for Regular Regions Using the Optimized Canonical Transformation Method — Arnd Bäcker[1,2], Roland Ketzmerick[1,2], •Clemens Löbner[1,2], and Steffen Löck[1] — [1]Technische Universität Dresden, Institut für Theoretische Physik, 01062 Dresden — [2]MPI für Physik komplexer Systeme, 01187 Dresden

Our aim is to approximate the dynamics of a regular island in a non-integrable Hamiltonian H by an integrable Hamiltonian H_{reg}. For this purpose we introduce optimized canonical transformations in phase space such that the regular dynamics of H and H_{reg} agree as closely as possible.

We apply this optimized canonical transformation method to the standard map and the cosine billiard. In the second case the resulting integrable Hamiltonian describes a billiard with the same boundary, but a nontrivial time evolution. This provides a basis for the future determination of regular-to-chaotic tunneling rates for generic billiards with the fictitious integrable system approach.

DY 29.5 Thu 17:00 Poster A

Spectral Statistics in Systems with a Mixed Phase Space — Arnd Bäcker[1,2], •Steffen Löck[1], Normann Mertig[1,2], and

Torsten Rudolf[1] — [1]Technische Universität Dresden, Institut für Theoretische Physik, 01062 Dresden — [2]MPI für Physik komplexer Systeme, 01187 Dresden

We study the consequences of flooding on spectral statistics in systems with a mixed phase space, in which regions of regular and chaotic motion coexist. With increasing density of states we observe a transition of the level-spacing distribution $P(s)$ from Berry-Robnik to Wigner statistics, although the underlying classical phase space remains unchanged. In order to explain this transition we present a flooding improved Berry-Robnik distribution which accounts for the disappearance of regular states. Furthermore, we extend this prediction by explicitly considering the tunneling couplings between regular and chaotic states [1]. We show that this approach excellently reproduces the observed transition of the level-spacing distribution and additionally describes the power-law level repulsion at small spacings.

[1] A. Bäcker, R. Ketzmerick, S. Löck, and N. Mertig, Phys. Rev. Lett. **106**, 024101 (2011).

DY 29.6 Thu 17:00 Poster A

Dynamical tunneling in 4D maps — Arnd Bäcker[1,2], Roland Ketzmerick[1,2], and •Martin Richter[1] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany

Higher dimensional Hamiltonian systems show an involved phase-space structure including regular regions interwoven with chaotic trajectories of the Arnol'd web. For 4D quantum maps we investigate the regular-to-chaotic tunneling rates out of mostly regular region embedded inside a large chaotic sea. The tunneling rates are predicted using the fictitious integrable system approach. We address the consequences of resonances on the tunneling rates. Furthermore we study chaotic states approaching the Arnol'd web from outside.

DY 29.7 Thu 17:00 Poster A

Trapping of chaotic orbits in 4D maps — Arnd Bäcker[1,2], Roland Ketzmerick[1,2], •Steffen Lange[1], and Martin Richter[1] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany

Generic Hamiltonian systems with more than two degrees of freedom lead to chaotic zones in phase space which are all interconnected by the Arnol'd web. We study 4D maps with a regular region embedded in a large chaotic sea, i.e. far away from the near-integrable regime. We investigate chaotic orbits trapped in the vicinity of the regular region for long times. These are visualized by 3D sections of the 4D phase space. We search for the trapping mechanism by analyzing the fractal dimension and time-dependent frequencies of trapped orbits.

DY 29.8 Thu 17:00 Poster A

The stationary state of time-periodically driven ideal gases coupled to a thermal bath. — •Daniel Vorberg[1,2], Waltraut Wustmann[2], André Eckardt[1], and Roland Ketzmerick[1,2] — [1]Max-Planck-Institut fuer Physik komplexer Systeme, Noethnitzer Str. 38, 01387 Dresden — [2]Institut fuer Theoretische Physik, Technische Universitaet Dresden, 01062 Dresden

Time-periodically driven quantum systems that are coupled to a thermal bath possess a stationary state that generically does not obey detailed balance. We consider ideal gases of many non-interacting bosonic or fermionic particles and show that, as a consequence, their stationary state is generally not described by a Gaussian density operator. Accordingly, also Wick's theorem does not hold. This contrasts the behavior of non-driven systems. However, studying rather generic time-periodically forced model systems with regular and chaotic states, we find that a Gaussian ensemble can still be a very good approximation to the stationary state. Hence, Wick's decomposition of n-particle correlation functions is possible in an approximative sense.

DY 29.9 Thu 17:00 Poster A

Spin transport in the XXZ model at high temperatures: Classical dynamics versus quantum $S = 1/2$ autocorrelations — •Robin Steinigeweg — J. Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia

The transport of magnetization is analyzed for the classical Heisenberg chain at and especially above the isotropic point. To this end, the Hamiltonian equations of motion are solved numerically for initial states realizing harmonic-like magnetization profiles of small amplitude and with random phases. Above the isotropic point, the resulting dynamics is observed to be diffusive in a hydrodynamic regime starting at comparatively small times and wave lengths. In particular, hydrodynamic regime and diffusion constant are both found to be in quantitative agreement with close-to-equilibrium results from quantum $S = 1/2$ autocorrelations at high temperatures. At the isotropic point, the resulting dynamics turns out to be non-diffusive at the considered times and wave lengths.

DY 29.10 Thu 17:00 Poster A

The Van Vleck propagator for bosonic fields — •Thomas Engl, Juan-Diego Urbina, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg

In single particle physics semiclassics provides a very powerful toolbox consisting of *e.g.* the Van Vleck propagator and Gutzwiller's Green function which are calculated from the properties of the real classical trajectories only.

We have derived an analogue of the Van Vleck propagator for bosonic quantum fields based on the usage of quadratures. We sketch the derivation of the propagator and present some applications to the Bose-Hubbard model as well.

DY 29.11 Thu 17:00 Poster A

Surface melting of wet granular matter in two dimensions — Christopher May, •Kai Huang, and Ingo Rehberg — Experimentalphysik V, Universitaet Bayreuth, 95440 Bayreuth, Germany

The transition from the solidlike to the liquidlike state of a monolayer of wet glass beads under horizontally swirling motion is investigated experimentally. Due to the cohesion arising from the formation of capillary bridges, the wet particles initially form a crystal like structure at moderate driving. As the driving frequency increases, this structure is found to melt with two steps: A rearrangement into a hexagonal packing sheltered by a premelted layer, followed by a melting from the surface. This process is characterized by means of Voronoi tessellation and bond orientational order parameters, and discussed within the scenario of KTHNY theory that accounts for crystal melting in two dimensions.

DY 29.12 Thu 17:00 Poster A

Phase Transitions in 2D colloidal systems subject to substrate-induced random potentials — •Sven Deutschländer, Georg Maret, and Peter Keim — University of Konstanz, Department of Physics, 78457, Konstanz, Germany

We investigate the effect of substrate-induced random potentials on the thermodynamics of a two-dimensional colloidal system with magnetic dipol-dipol interaction. In particular, we are interested in the structure and dynamics of possible phases, the order and mechanism of the phase transitions, and transition temperatures as a function of strength and randomness of the external potential. We show that the first occurrence of hexatic characteristics as well as the transition to a crystalline state are, triggered by the substrate potential, shifted to lower temperatures which is in agreement with theories by D. Nelson, and M.-C. Cha and H. Fertig. Further, we found that, at finite randomness and low system temperatures, the system occupies a solid state. This verifies simulations by S. Herrera-Velarde and H. H. von Grünberg, as well as Cha and Fertig's reconsiderations of Nelson's theory. The latter postulates a re-entrance from the solid to the hexatic phase at low temperatures for arbitrary small randomness what is not seen in our experiment. In addition, we observe the developing of phase equilibria indicating first order characteristics which also seem to be induced by the external potential, and show that their range is dependent on the randomness.

DY 29.13 Thu 17:00 Poster A

Loop length distributions in the Negative Weight Percolation (NWP) problem: Extension to 4 to 7 dimensions — •Gunnar Claussen, Oliver Melchert, and Alexander K. Hartmann — Institut für Physik, Carl-von-Ossietzky-Universität Oldenburg

The negative weight percolation (NWP) problem [1] on hypercubic lattice graphs is a bond percolation problem with disorder distributions that allow for edge weights of either sign. Under variation of the concentration ρ of negative edge weights "small" and percolating loops of total negative weight are found. The NWP problem shows no transitivity and has no simple definition of clusters, therefore it fundamentally differs from conventional percolation problems. A numerical examination of the models requires a sophisticated transformation of the original graph and the application of matching algorithms in order to find the minimum-weighted configuration of loops.

Here, we study the problem by numerical methods for ρ below the critical point ρ_c, where system-spanning loops appear. The core of the examination is the determination of the Fisher exponent τ, which describes the loop length distribution according to $n(l) \propto l^{-\tau}$, and the loop-size cut-off exponent σ. The latter determines the line tension T_L of the non-pecolating loops by $T_L(\rho) \propto |\rho - \rho_c|^{1/\sigma}$ and complies to a cut-off in loop lengths for $\rho < \rho_c$. In extension of previous works the model is examined for dimensions $d = 4...7$. The results are compared to previous finite-size scaling analyses [2].

[1] O. Melchert and A.K. Hartmann, New J. Phys. 10 (2008) 043039
[2] O. Melchert, L. Apolo and A.K. Hartmann, PRE 81 (2010) 051108

DY 29.14 Thu 17:00 Poster A

Perfect conducting channel in two-dimensional random lattices with XY-disorder and engineered hopping amplitudes — •Alberto Rodriguez[1,3], Arunava Chakrabarti[2], and Rudolf A. Römer[3] — [1]Phisikalisches Institut, Albert-Ludwigs Universität Freiburg, Hermann-Herder Strasse 3, D-79104, Freiburg, Germany — [2]Department of Physics, University of Kalyani, Kalyani, West Bengal-741 235, India — [3]Department of Physics and Centre for Scientific Computing, University of Warwick, Coventry, CV4 7AL, United Kingdom

We study the spectral and transport properties of two-dimensional lattices with random on-site energies $\epsilon_{x,y}$, and random vertical hopping amplitudes $\gamma_{(x,y)\to(x,y+1)}$. The disorder in the system is defined by three independent random sequences $\{\alpha_x\}, \{\beta_y\}, \{\xi_y\}$, in the following way: $\epsilon_{x,y} = \alpha_x\beta_y$, and $\gamma_{(x,y)\to(x,y+1)} = \alpha_x\xi_y$. By engineering the random distribution ξ_y, a full band of Bloch states emerges in the spectrum, and a perfect conducting channel in the x direction is induced in the system. We describe how to create the conductance channel in finite systems, and we study its robustness against deviations from the ideal requested values for ξ_y. Remarkably, we demonstrate that the channel persists in the thermodynamic limit —for the infinite two-dimensional system—. Furthermore, we also discuss how to modify the localization of the eigenstates almost at will in the x and y directions. Our results are constructed analytically and supported by extensive numerical calculations of localization lengths, conductance and density of states.

DY 29.15 Thu 17:00 Poster A

Efficient implementation of Sweeny's algorithm for simulations of the Potts model — •Eren Elçi[1] and Martin Weigel[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, 55099 Mainz, Germany — [2]Applied Mathematics Research Centre, Coventry University, Coventry, CV1 5FB, England

The simulation of spin models close to points of continuous phase transitions is heavily impeded by the occurrence of critical slowing down. A number of cluster algorithms usually based on the Fortuin-Kasteleyn representation of the Potts model and suitable generalizations for continuous-spin models has been used to increase simulation efficiency. The first algorithm making use of this representation, suggested by Sweeny in 1983, has not found widespread adoption due to problems in its efficient implementation. It has been shown recently, however, that it is indeed more efficient in reducing critical slowing down that the more well-known variants due to Swendsen/Wang and Wolff. Here, we discuss efficient implementations of Sweeny's approach based on union-and-find algorithms and using recent algorithmic advances in dynamic connectivity algorithms, and show how these can be used for efficient simulations in the random-cluster model.

DY 29.16 Thu 17:00 Poster A

Mixed Ising ferrimagnets with next-nearest neighbour couplings on square lattices — •Walter Selke[1] and Cesur Ekiz[2] — [1]Institut für Theoretische Physik der Phasenübergänge, RWTH Aachen — [2]Department of Physics, Adnan Menderes University, Aydin

We study Ising ferrimagnets on square lattices with antiferromagnetic exchange couplings between spins of values S=1/2 and S=1 on neighbouring sites, couplings between S=1 spins at next–nearest neighbour sites of the lattice, and a single–site anisotropy term for the S=1 spins. Using mainly ground state considerations and extensive Monte Carlo simulations, we investigate various aspects of the phase diagram, including compensation points, critical properties, and temperature dependent anomalies. In contrast to previous belief, the next–nearest neighbour couplings, when being of antiferromagnetic type, may lead to compensation points. W. Selke and C. Ekiz, J. Phys. C: Condensed Matter 23, 496002 (2011); W. Selke and J. Oitmaa, J. Phys. C: Condensed Matter 22, 076004 (2010)

DY 29.17 Thu 17:00 Poster A

Mean-field theory of Active Brownian particles with velocity-alignment — •Robert Grossmann[1], Pawel Romanczuk[1,2], and Lutz Schimansky-Geier[1] — [1]Department of Physics, Humboldt-Universität zu Berlin, Newtonstraße 15, 12439 Berlin, Germany — [2]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany

A model of active Brownian particles with velocity-alignment in two spatial dimensions is introduced. The individual dynamics is based on the so called Schienbein-Gruler model as well as thermal and active fluctuations. A macroscopic description is derived directly from the microscopic Langevin dynamics via a nonlinear Fokker-Planck equation and a moment expansion of the corresponding probability density function. We discuss the impact of different fluctuation types on the onset of collective motion, i.e. noise induced bistabilities.

DY 29.18 Thu 17:00 Poster A

One dimensional transport of colloids with attractive interactions — •Dortje Schirok, Ken Lichtner, and Sabine H.L. Klapp — Institute of Theoretical Physics, Secr. EW 7-1, Technical University Berlin - Hardenbergstr. 36, D-10623 Berlin, Germany

Considering a non-equilibrium one-dimensional system of interacting colloids in a tilted washboard potential, we find a certain flux of the center of mass along the congruent axis [1]. By adding an additional attractive part to the colloid's profile this flux is damped. In the time dependence of the mean-squared displacement we see the colloids being trapped for a certain time before going to the diffusive regime [2]. This system is examined with and without the attractive part to the colloid's potential. Furthermore we studied the effect of the potential's interaction stiffness on the transport mechanisms.

[1] K. Lichtner and S.H.L. Klapp, Europhys. Lett 92, 40007 (2010)
[2] R. Gernert, K. Lichtner, D. Schirok, S.H.L. Klapp, to be published

DY 29.19 Thu 17:00 Poster A

Characterizing heterogeneous diffusion by the distribution of diffusivities — •Michael Bauer and Günter Radons — Chemnitz University of Technology, Germany

Heterogeneous diffusion processes arise in many physical and biological applications where the diffusive behavior changes during the motion. For instance, diffusion in ultra-thin liquid films is governed by layer-dependent diffusion coefficients and jumps between the liquid layers. The observation of individual tracers by single-particle tracking (SPT) allows for a characterization of such processes. Hence, we suggested to investigate the distribution of diffusivities and their dependence on the time lag between snapshots [1]. This analysis should be preferred to conventional methods such as mean-squared displacements which conceal the effects of inhomogeneities. We also studied the relation to ensemble-based measurements obtained from pulsed field gradient nuclear magnetic resonance (PFG NMR) and applied it to the two-region exchange model [2]. In our contribution we extend the investigations to systems in the presence of observation noise, which is of high relevance for experimental data. Moreover, our objective is to consider higher moments of the distribution of diffusivities and their dependence on the time lag, which characterizes the diffusivity as a fluctuating quantity along a trajectory.

[1] M. Bauer et al., Diffus. Fundam. 11, 104 (2009)
[2] M. Bauer et al., J. Chem. Phys. 135, 144118 (2011)

DY 29.20 Thu 17:00 Poster A

Characterizing anisotropic diffusion via distribution of generalized diffusivities — •Mario Heidernätsch and Günter Radons — Chemnitz University of Technology, D-09126 Chemnitz, Germany

Anisotropic diffusion is one possible generalization of the homogeneous diffusion process. It occurs typically in anisotropic media such as liquid crystals and can be formally described by a Fokker-Planck-equation using a diffusion tensor. In experiments single molecule tracking often is used to observe the local diffusion properties of a tracer in a liquid. Due to the experimental setup only a projection of the diffusion volume is observed, in other words a projected diffusion tensor. We now apply our distribution of generalized diffusivities [1] to this projected

anisotropic diffusion and assess the properties of the underlying process. Our objective is in particular to discriminate between anisotropic and heterogeneous diffusion processes.
[1] M. Bauer et al., J. Chem. Phys. 135, 144118 (2011)

DY 29.21 Thu 17:00 Poster A

Effective diffusion and quasi-deterministic transport of Brownian particles in a spatio-temporally oscillating potential — •Pawel Romanczuk[1], Felix Müller[2], and Lutz Schimansky-Geier[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden — [2]Institut für Physik, Humboldt Universität zu Berlin, 12489 Berlin

We consider overdamped Brownian dynamics in an temporally oscillating and spatially periodic potential. We analyze the non-directed diffusive transport which shows oscillation induced enhancement of the effective diffusion and present an approximate formula for the effective diffusion coefficient. Furthermore we analyze the effect of the oscillating potential on directed transport due to the application of a constant force. We show via numerical simulations the existence of an optimal force at which the deterministic dynamics is in resonance with the potential oscillations giving rise to directed transport with extremely low dispersion.

[1] P Romanczuk, F Müller,L Schimansky-Geier, Quasi-deterministic transport of Brownian particles in an oscillating periodic potential, *Phys. Rev. E*, **81**, 061120 (2010)

[2] F Müller, P Romanczuk, L Schimanksky-Geier, Synchronization and Transport in an oscillating periodic potential, *Stochastics and Dynamics*, **11**, 2-3 (2011)

DY 29.22 Thu 17:00 Poster A

Forced Kramers escape with memory friction — •Jakob Tómas Bullerjahn, Sebastian Sturm, Lars Wolff, and Klaus Kroy — Institut für Theoretische Physik, Universität Leipzig, Germany

Starting from a generalized Langevin equation with arbitrary memory kernel, we describe the irreversible escape from a potential well, driven by a time-dependent external force protocol. Our model is analytically tractable and rectifies the unphysical behaviour of the escape rate under large pulling forces present in established models of stochastic bond breaking [1,2]. Beyond the Markovian limit, our approach directly applies to subdiffusive biological systems such as semiflexible polymers or membranes.

[1] Dudko, Hummer, Szabo, Phys. Rev. Lett. 96, 108101 (2006)

[2] Freund, PNAS 106, 8818 (2009)

DY 29.23 Thu 17:00 Poster A

Probing anomalous diffusion in a polymer melt with a continuous-time random walk ansatz — •Julian Helfferich[1], Falko Ziebert[2], Hendrik Meyer[2], Alexander Blumen[1], and Jörg Baschnagel[2] — [1]Theoretical Polymer Physics, University of Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg, Germany — [2]Institut Charles Sadron, Université de Strasbourg, CNRS, 23 rue du Loess, 67037 Strasbourg Cedex, France

Continuous time random walks (CTRW) have been repeatedly advanced for describing the dynamics of low-temperature polymer melts and binary mixtures. A CTRW picture allows for a systematic description of the long-time dynamics, averaging over the strongly correlated motions on small time- and length-scales; in this way it also serves in analysing the results of molecular dynamics (MD) simulations, allowing to determine the relevant parameters.

Using MD simulations we analyse the single particle trajectories, identify jumps and determine the waiting time and jump length distributions. Furthermore, based on tests for correlations, we determine the time- and length-scales on which the CTRW description is adequate.

DY 29.24 Thu 17:00 Poster A

Anomalous diffusion analyzed in terms of the distribution of generalized diffusivities — •Tony Albers and Günter Radons — Chemnitz University of Technology, Germany

We investigate two systems that show anomalous diffusion. The first one is the continuous time random walk model with an algebraically decaying waiting time distribution that does not have a finite first moment. This model shows subdiffusive behavior and exhibits so called Weak Ergodicity Breaking. Secondly, we consider the Hamiltonian dynamics of particles under the influence of quenched spatial disorder. Both systems are analyzed by a new tool that we call the distribution of generalized diffusivities $p_\alpha(D,\tau)$. This distribution is defined as the probability density to find a squared displacement of duration τ divided by the asymptotic time dependence of the mean squared displacement τ^α. Hence this distribution describes the fluctuations during the diffusion process around the generalized diffusion coefficient that can be obtained from the mean squared displacement and is also equal to the first moment of the distribution $p_\alpha(D,\tau)$. In this contribution we show for the subdiffusive continuous time random walks how the ensemble-averaged and time-averaged distribution of generalized diffusivities are related to each other and how the anomalous diffusion in phase space can be explained by a modified Levy walk model, which is deduced from the distribution of generalized diffusivities.

DY 29.25 Thu 17:00 Poster A

Investigation of dielectric and elastic properties of glasses at very low temperatures in the low frequency regime — •Annina Luck, Marius Hempel, Andreas Reiser, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg

In the last years, measurements of dielectric two-pulse polarisation echoes have revealed that nuclear electric quadrupole moments involved in atomic tunneling sytems can accord for the magnetic field dependence of the echo amplitude of non-magnetic glasses.

To investigate the influence of nuclear electric quadrupoles on the low frequency dielectric and elastic properties of glasses down to a temperature of 7 mK, we measured samples of the glass N-KZFS11 which contains 25 mass percent of tantalum oxide. As ^{181}Ta carries a very large nuclear electric quadrupole moment, the measured sample seems to be an ideal candidate to determine the influence of nuclear electric quadrupole moments on the physical properties of glasses at low temperatures.

The tunneling model predicts a slope ratio of 2 for the logarithmic temperature dependence of the susceptibility, caused by resonant and relaxational processes. Our results show a surprising accordance with this prediction of the tunneling model, which as of now has never been observed in other glasses.

We discuss these experimental results in the context of the tunneling model and possible extensions of it.

DY 29.26 Thu 17:00 Poster A

Thermal Conductivity of Normal Conducting and Superconducting Bulk Metallic Glasses at Very Low Temperatures — •Daniel Rothfuss[1], Uta Kühn[2], Andreas Fleischmann[1], and Christian Enss[1] — [1]Kirchhoff-Institute for Physics, Heidelberg University, INF 227, 69120 Heidelberg — [2]IFW Dresden, Institute for Complex Materials, P.O. Box 270116, 01171 Dresden

Bulk metallic glasses (BMG) have been produced for more than one decade, but their low temperature properties are still mostly unexplored although BMGs represent a new and very interesting kind of amorphous material with a wide range of electric and magnetic properties. At low temperatures the physical properties of non-magnetic BMGs should be governed by atomic tunneling systems, phonons and conduction electrons as well as the interactions among these degrees of freedom. We recently started the investigation of the thermal properties of superconducting BMGs well below T_c, as in these samples the electronic degree of freedom can be switched on and off by an external magnetic field. We present the thermal conductivity of a Zr based BMG in the superconducting state down to 6 mK. Our results show that sufficiently far below T_c the thermal conductivity can be described by the thermal diffusion of phonons and their resonant scattering with tunneling systems. Furthermore we present the thermal conductivity of the normal conducting BMG $Au_{49}Ag_{5.5}Pd_{2.3}Cu_{26.9}Si_{16.3}$ in the temperature range between 10 mK and 250 mK.
Both measurements were performed with a SQUID-based contact free technique with extremely small parasitic heating.

DY 29.27 Thu 17:00 Poster A

Non-linear single-particle-response of glassforming systems to external fields — •David Winter[1], Peter Virnau[1], Jürgen Horbach[2], and Kurt Binder[1] — [1]Johannes Gutenberg-Universität, Mainz, Germany — [2]Heinrich Heine-Universität, Düsseldorf, Germany

In this work, we study the behavior of single particles in a supercooled liquid under the influence of an external force. Our model system is a 50:50 binary mixture whose particles interact via a Yukawa potential. In the equilibrated system, we add a constant force field to one of these particles which as a consequence will be accelerated. After some time, this particle reaches a steady state. In this state we measure characteristic properties of the particle and the surrounding like the steady state velocity, the friction coefficient, mean square displacements and correlation functions in dependence of the external force and system temperature. We observe that for low temperatures and high enough force fields the particle leaves the linear response regime and enters the non-linear regime. Here, the friction coefficient is not constant any more. For even higher forces all curves reach a second plateau and fall on top of each other.

DY 29.28 Thu 17:00 Poster A

Colloidal structures on quasicrystalline substrates — •Matthias Sandbrink and Michael Schmiedeberg — Institut für Theoretische Physik 2: Weiche Materie, Heinrich-Heine-Universität Düsseldorf

Colloidal suspensions, dispersions of micro-sized particles in a fluid, are a well known model system in statistical physics. The behavior of such particles on substrates is important for a lot of applications like photonic crystals, colloidal nanofilms, or novel materials with special rheological or frictional properties. As substrate we consider different aperiodic tilings with long-range order. By using Monte-Carlo simulations, we study the growth process of colloidal structures on such quasicrystalline substrates. Our goal is to grow colloidal quasicrystals in a controlled way.

DY 29.29 Thu 17:00 Poster A

Critical Casimir forces in many-body systems — •Thiago Mattos[1], Ludger Harnau[1,2], and Siegfried Dietrich[1,2] — [1]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Deutschland — [2]Institut für Theoretische und Angewandte Physik, Stuttgart, Deutschland

The confinement of a binary liquid mixture close to its critical (demixing) point leads to effective critical Casimir forces between the confining boundaries. These long-ranged forces can be either attractive or repulsive depending on the choice of the boundary conditions, i.e. the preference of the confining surfaces in adsorbing one of the two components of the liquid mixture. We investigate the effect of many-body interactions in the Casimir force, which is expected to be non-additive, for two spherical colloids close to a wall immersed in a binary liquid mixture close to criticality. We calculate this force for three different systems: (i) single spherical colloid close to a wall, (ii) two spherical colloids and (iii) two spherical colloids close to a wall. For all systems we consider several combinations of boundary conditions for the colloids and for the wall.

DY 29.30 Thu 17:00 Poster A

Spontaneous imbibition in a network of nanopores: A numerical study — •Zeinab Sadjadi and Heiko Rieger — Saarland University, Saarbrücken, Germany

We study numerically the spontaneous imbibition of water into nanoporous Vycor glass (NVG). NVG is a silica substrate with an interconnected network of cylindrical pores with characteristic radii of 3-5 nm, which we model by a two-dimensional network of cylindrical pipes with random radii and different aspect ratios. We model the spontaneous rise of water by solving the mass balance equation at each node. We analyze the temporal evolution of the average height and width of the invasion front. Our results predict an unusually weekly correlated menisci motion and an anomalously strong roughening of imbibition fronts. These findings, which are also observed experimentally by neutron imaging, show that spontaneous imbibition crucially depends on pore aspect ratio and reveal a new universality class of imbibition behaviour which is expected to occur in any matrix with elongated pores.

DY 29.31 Thu 17:00 Poster A

Drying fronts in colloidal films — Joaquim Li[1], Bernard Cabane[1], •Jan S. Vesaratchanon[2], Michael Sztucki[3], Jeremie Gummel[3], and Lucas Goehring[2] — [1]PMMH, ESPCI, Paris, France — [2]MPI for Dynamics and Self-Organization, Göttingen, Germany — [3]ESRF, Grenoble, France

The drying of a colloidal film involves multiple transport processes, with the film properties changing dramatically as drying proceeds. Many such films are applied as a liquid dispersion, begin to dry from the edges inward (directional drying), and change into a porous solid as the result of evaporation. In two extreme situations the film may either dry into a flat, homogeneous layer, or may dry via the iconic 'coffee-ring' effect, where nearly all solid material is deposited at the edge of the film. However, the conditions that discriminate between these two limits are not understood, nor is the general physics controlling dispersant/particle transport during drying. We have studied this problem via Small Angle X-ray/Neutron Scattering, on directionally dried films of colloidal silica, whereby we measure the ordering of particles, their volume fraction, the film thickness and the water content simultaneously. We find that far from an edge, where a flat film develops, all material transport occurs in a thin transition region, of finite width, that propagates ahead of the drying front. In this region, like a polarization wave in filtration experiments, the gradient of osmotic pressure balances the drag force exerted on the particles by capillary flow toward the liquid-solid front. The growth or decay of such a region may lead to uneven deposits, such as ridges near the film edges.

DY 29.32 Thu 17:00 Poster A

Motional patterns of particle trains in a microchannel — •Sebastian Reddig and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, D-10623 Berlin, Germany

Microfluidic devices have emerged as powerful tools for manipulating, controlling, and analyzing various processes in chemistry, physics and biology. With the help of such devices one can make controlled studies on the influence of confinement and can easily drive suspended objects out of equilibrium, using a pressure driven Poiseuille flow. Thereby one can induce novel and intriguing dynamic structure formation in complex fluids, whose knowledge is essential, e.g., for developing tools to transport and sort particles on the micron scale.

We introduce a model for particle trains under the influence of a pressure driven flow, which are confined between two planar parallel walls. The colloids are neutrally buoyant and interact hydrodynamically via the solvent. We describe hydrodynamic interactions with the two-wall Green tensor that takes into account the no-slip condition at the walls[1]. We show that different initial conditions lead to different motional patterns, where the particle trains either form a propagating wave or one particle oscillates back and forth between its neighbors. We analyze the stability of these patterns and investigate how they depend on the ratio of colloid radius and channel width.

[1] *Spherical particle in Poiseuille flow between planar walls*, J. Chem. Phys, **121**, 483 (2004).

DY 29.33 Thu 17:00 Poster A

Bidisperse ferrofluid microstructure in a monolayer — •Elena Minina[1,3], Alla Muratova[1], Joan Cerda[2], Sofia Kantorovich[1,3], and Christian Holm[3] — [1]Ural Federal University, Lenin av. 51, Ekaterinburg, 620000, Russia — [2]Institute for Cross-Disciplinary Physics and Complex System, Campus Universitat de les Illes Balears, 07122, Palma de Mallorca — [3]Institut fuer Computerphysik, Universitaet Stuttgart, Pfaffenwaldring 27, 70569, Stuttgart, Deutschland

A bidisperse ferrofluid possesses a complex and versatile microstructure even in the absence of an external magnetic field. This system can be regarded as a model for a real polydisperse dipolar fluid. It is worth saying that the microstructure strongly depends not only on the polydispersity, but also on the sample geometry. It is well known that in three dimensions space there are three main chain classes [C. Holm at al, J. Phys.: Cond. Mat. 18 (2006)], but in the case of a constraint geometry (quasy-2D) it is necessary to consider 19 classes of chains, rings and single particles for the description of the microstructure in terms of a classical density functional theory that compared well to results obtained via by molecular dynamics simulations. The calculation of the virial coefficients allows us to demonstrate the influence of the geometry on the interparticle interaction and, as a result, on the cluster formation. In our contribution we compare the probabilities for chain formation of different length and particle composition in the 3D and quasy-2D geometries and also confirm the distinction of the microstructures in the geometries by using virial coefficients.

DY 29.34 Thu 17:00 Poster A

Structure and dynamics of suspensions of colloidal dumbbells — •Nils Heptner and Joachim Dzubiella — Helmholtz Zentrum Berlin, Germany

We investigate the static and dynamic structure of suspensions of colloidal dumbbells using Brownian dynamics computer simulations. The particular focus is the study of bulk structure at different densities and the dynamical properties under shear flow. We present preliminary results on the static structure factor, its response to shear, and stress-strain relations in the sheared purely liquid state.

DY 29.35 Thu 17:00 Poster A

Pulsed chaos synchronization in networks with adaptive couplings — •Marco Winkler and Wolfgang Kinzel — Institute for Theoretical Physics, University of Würzburg, Am Hubland, 97074 Würzburg, Germany

Networks of chaotic units with *static* couplings can synchronize to a common chaotic trajectory. The effect of *dynamic adaptive* couplings on the cooperative behavior of chaotic networks is investigated. The couplings adjust to the activities of its two units by two competing mechanisms: An exponential decrease of the coupling strength is compensated by an increase due to de-synchronized activity. This mechanism prevents the network from reaching a steady state. Numerical simulations of a coupled map lattice show chaotic trajectories of de-synchronized units interrupted by pulses of mutually synchronized clusters. These pulses occur on all scales, sometimes extending to the entire network. The fraction of synchronized pairs, as well as the duration of the pulses show a power-law distribution. Synchronization clusters can be triggered by stimulating a small group of synchronized units.

DY 29.36 Thu 17:00 Poster A

Effects of introducing a competing salmon species into a model of sockeye salmon population dynamics — •Christoph Schmitt[1], Barbara Drossel[1], and Christian Guill[2] — [1]Institut für Festkörperphysik, TU Darmstadt — [2]J.F. Blumenbach Institute of Zoology and Anthropology, Georg-August-University Göttingen

The number of spawning sockeye salmon in the Fraser River basin in Canada shows a remarkably strong and regular four-year oscillation. This so-called cyclic dominance phenomenon is reproduced as a stable attractor by a recently introduced three species model for salmon fry, their zooplankton food, and their main predator in the rearing lakes, rainbow trout.

However, this simple model does not take into account that all sockeye rearing lakes also contain kokanee salmon, which belong to the same species as sockeye. Unlike sockeye, which migrate to the ocean at age one, kokanee spend their entire life in the lakes.

We investigate the dynamics of models that include kokanee salmon in addition to the other three species. This increases the predator biomass by providing a stable food source. In the simplest version of the four-species model, cyclic dominance breaks down over a large parameter range, because it reduces the required strong coupling between sockeye and their predators. Because cyclic dominance is observed in nature nevertheless, we also study other versions of the four-species model. In particular, we investigate whether splitting kokanee and/or rainbow trout into different age classes can increase the parameter range over which cyclic dominance is observed.

DY 29.37 Thu 17:00 Poster A

Boundary effects in spatially embedded networks — •Aljoscha Rheinwalt — Potsdam Institute for Climate Impact Research, Germany — Humboldt University of Berlin, Germany

What is the influence of boundaries in spatially embedded networks on network measures? A question that can be answered by a statistical method with the use of appropriate surrogate networks. This is shown by examples with the network measures degree, closeness centrality and shortest path betweenness.

DY 29.38 Thu 17:00 Poster A

Intrinsic Plasticity of Leaky Integrators Through Stochastic Adaptation — •Mathias Linkerhand and Claudius Gros — Institute for Theoretical Physics, Johann Wolfgang Goethe University, Frankfurt am Main, Germany

Intrinsic plasticity denotes the adaption of internal neural parameters, such as threshold and gain. It has been introduced and studied for discrete-time neurons. Since real world neurons respond continuously in time, here we introduce a continuous-time model of intrinsic plasticity in neurons. In this work we use rate coding leaky integrators. We show that the firing rate distribution of a single neuron efferently connected to a random noise input is driven by a target distribution through stochastic adaptation. For some target distributions this leads to self-organized stochastic escape. We also discuss the response to different kind of input stimuli and the behavior of small networks.

DY 29.39 Thu 17:00 Poster A

Structure of complex networks for minimizing traffic congestion and cost — Jelena Smiljanjić and •Igor Stanković — Scientific Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

In process of design of optimal network, it is necessary to understand how traffic flow depends on network structure. We study data packet flow on complex networks, where the packet delivery capacity of each node or link is fixed. The comparison has been made on the following complex-network topologies: random, distance model, and regular. The optimal configuration of capacities to minimize traffic congestion is analyzed and the critical packet generating rate is determined, below which the network is at a free flow state but above which congestion occurs. The congestion is analyzed in comparison with cost of such network measured in number and length of the links or their capacity. Our analysis reveals a direct relation between network topology and traffic flow. Our analysis also makes it possible to compare the congestion conditions for different types of complex networks. In particular, we find that network with low critical generating rate is more susceptible to congestion.

DY 29.40 Thu 17:00 Poster A

Stochastic Analysis of Rogue Waves — •Ali Hadjihosseini, Matthias Wächter, and Joachim Peinke — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg

We present an analysis of rogue wave data, with a stochastic approach based on the theory of Markov processes. In many cases Markov processes can be described completely by a Fokker-Planck or Langevin equation with parameters derived directly from experimental data. The method was applied to rogue wave measurement data. Their Markov properties were shown and first estimations for the parameters of the Fokker-Planck equation were performed.

DY 29.41 Thu 17:00 Poster A

Travelling wave solutions for multiphase flow in porous media — •Oliver Hönig[1] and Rudolf Hilfer[1,2] — [1]Institut für Computerphysik, Universität Stuttgart, 70569 Stuttgart, Deutschland — [2]Institut für Physik, Universität Mainz, 55099 Mainz,Deutschland

We study travelling wave solutions of multiphase flow in one-dimensional porous media on a macroscopic scale. A dimensionless system of two fractional flow equations with coupled flow functions and simplified capillarity is employed to formulate a dynamical system. This system is discussed in detail with analytical and numerical methods. It leads to a more complex behaviour than the case of a single fractional flow equation.

DY 29.42 Thu 17:00 Poster A

Quantitative validation of multi-scale modelling of porous media — •Andreas Lemmer and Rudolf Hilfer — Institut für Computerphysik, Universität Stuttgart, 70569 Stuttgart, Deutschland

Flow and transport through geological, biological and industrial porous media typically involve multiple length and/or time scales. Controlled approximations with quantitative error indicators on different scales are necessary to develop multi-scale models from single-scale approaches and to verify them. Based on a continuum model for porous media, we discretize three-dimensional images of a synthetic sample of a Fontainebleau sandstone with side length 1.5 cm at resolutions covering three decades from 117 μm down to 458 nm [1]. Calculating and analyzing geometric and transport parameters at different resolutions allow quantitative validation of different theoretical approaches and comparison with experiment.

[1] R. Hilfer and T. Zauner: High precision synthetic computed tomography of reconstructed porous media, Physcial Review E, in print (2011)

DY 29.43 Thu 17:00 Poster A

Comparison of paired and independent forecast ensembles by univariate and multivariate skill measures — •Stefan Siegert and Holger Kantz — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

A forecast ensemble is a collection of runs of a numerical model. The ensemble members are constructed by adding perturbations to the observed initial state (the analysis). In numerical weather prediction, the spread of such a forecast ensemble is used to estimate the uncertainty of the numerical model about the future state of the atmosphere.

The generation of perturbations for weather forecast ensembles is non-trivial and computationally expensive. A cheap method to increase K, the total number of ensemble members, without having to calculate further perturbations is the construction of pairs of ensemble members, by adding and subtracting the same perturbation from the analysis. However, such an ensemble can only span a (K/2)-dimensional subspace of the model space, whereas a fully independent ensemble can, in principle, span a K-dimensional subspace.

We study how well paired and fully independent ensembles are able to represent the variability of the verifying observation. We analyze their skill on a univariate (gridpoint-wise) basis, using the outlier statistic and the continuously ranked probability score. Further, ensemble variability is studied in a multivariate sense, using minimum spanning tree analysis. We find systematic differences between the two kinds of forecast ensembles.

DY 29.44 Thu 17:00 Poster A

Towards first-passage-time prediction in temperature time series — •Anja von Wulffen and Holger Kantz — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Current operational weather forecasts are based on detailed models run for a lead time of about ten days. Efforts to issue seasonal forecasts further into the future using similar models are still very experimental and deal with a high uncertainty. On these longer time scales, very specific prediction tasks such as the first passage time until a threshold crossing, e.g. the time until first frost, are of significant interest.

In order to see whether for such specific questions predictions based solely on a statistical analysis of the time series might not only require less resources than the full models but also yield better results, we study these first passage time distributions for actual temperature data and evaluate their potential predictability.

We also investigate the possibility of improvements through incorporating a second time series supplying information about the relevant slower-evolving atmospheric patterns such as the North Atlantic Oscillation.

DY 29.45 Thu 17:00 Poster A

Fluidization of wet granulates under hydrodynamic shear — •Christoph Goegelein, Ilenia Battiato, and Juergen Vollmer — Max-Planck-Institut fuer Dynamik und Selbstorganisation, Goettingen

Very recently, the fluidization threshold of wet granular beds under hydrodynamic shear forces were predicted theoretically [1]. This theory describes the flow through a wet granular bed by a continuum model and provides analytical expressions for the averaged drag force on a single particle. Moreover, the theory predicts the stability of the granular bed in dependence of the strength of the capillary and buoyancy forces. These theoretical predictions are tested in the present study by a newly designed flow channel. We will present our first experimental results for the fluidization onset of wet granular beds.

[1] I. Battiato, and J. Vollmer, "Fluidization of wet granulates under hydrodynamic shear", submitted for publication.

DY 29.46 Thu 17:00 Poster A

Anomalous diffusion of a fluid domain suspended in a wet granular gas — •Mitja Kleider[1,2], Klaus Röller[1], and Jürgen Vollmer[1,2] — [1]Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen — [2]Georg-August-Universität Göttingen

By event-driven molecular dynamics simulations we study the evolution of a dense fluid phase in a fluid-gas coexistence regime of wet granular matter where external driving balances the dissipation in the granular fluid. In a shallow two-dimensional system the fluid phase can form a domain of a well-defined width, a *granular droplet* immersed in the granular gas phase. Surprisingly, its centre-of-mass position exhibits Brownian motion with anomalous diffusion: the mean square displacement shows super-diffusive behaviour. The origin of the Brownian motion and the super-diffusive behaviour will be discussed.

DY 29.47 Thu 17:00 Poster A

Ergodic Theory, free cooling and steady states of three wet granular disks — •Jan-Hendrik Trösemeier and Jürgen Vollmer — MPI for Dynamics & Self-Organization, Göttingen

We extend the Sinai billiard to a model of three granular disks with minimal capillary interactions. These dissipative interactions lead eventually to a clustered state representing a frozen arrangement of the disks. To study the system in a steady state energy is injected by applying shearing via Lees-Edwards boundary conditions. This model system allows us to explore how the frozen state, which acts as an absorbing state in phase space, influences the dynamics of phase-space structure, invariant measures, and attractors. Surprisingly, the life-time distribution till a given initial condition reaches the frozen state shows an algebraic distribution, with a possibility that a finite number of initial conditions remain unbounded forever.

DY 29.48 Thu 17:00 Poster A

Fluctuation Dissipation Temperature in a Driven Granular Suspension — •Chih-Wei Peng and Matthias Schröter — Max-Planck-Institute for Dynamics and Self-Organization, Göttingen, Germany

The concepts of statistical mechanics have been widely applied to explain the phenomena observed in granular systems. Granular temperature in particular, is one of the most important quantities in the statistical approach to granular systems. Granular temperature can be defined on dynamical systems, namely, average kinetic energy temperature(T_{kin}) or fluctuation dissipation theorem based temperature(T_{FD})[1]. In our experiment, a torsion pendulum is set up, and one end of the pendulum is immersed into a granular suspension which is driven by water fluidization. By measuring the random torque due to the collision of particles and the dissipation of an external driven torque on the pendulum, we can obtain the energy scale which is related to fluctuation-dissipation temperature (T_{FD}). In addition, this setup can also be used to measure T_{FD} around the fluidization threshold, which can be related to glassy behavior.

[1] G. D'Anna, P. Mayor, A. Barrat, V. Loreto, and Franco Nori: *Nature* **424**, 909 (2003)

DY 29.49 Thu 17:00 Poster A

Transport Coefficients and Speed of Sound of a Granular Fluid from Static Correlation Functions — •Till Kranz[1,2] and Annette Zippelius[1,2] — [1]MPI für Dynamik & Selbstorganisation, Göttingen — [2]Institut für Theoretische Physik, Uni Göttingen

In order to reach a stationary state, granular, i.e., dissipative systems need an external driving. One of the many possible methods is to fluidize the system by a random force. It has been shown that the behavior of such a granular fluid on large length scales is well described by fluctuating hydrodynamics [1]. We exploit this description to extract material properties form event driven simulations.

For equilibrium fluids, the speed of sound, c, is directly related to the long wave length limit of the static structure factor, $S(q)$, via a fluctuation dissipation relation, $c^2 = k_BT/mS(q \to 0)$. We show that a generalized version of this relation also holds for the driven granular fluid. Using this relation, we measure the speed of sound of a granular fluid and find results that agree well with dynamic measurements [2] and with theoretical predictions.

The fluctuations dissipation theorem for equilibrium fluids makes it impossible to extract transport coefficients from static measurements. We show that, in contrast, it is possible to measure the viscosity of a granular fluid from the static current correlator.

[1] T. P. C. van Noije *et al.*, PRE 59, 4326 (1999)
[2] K. Vollmayr-Lee *et al.*, PRE 83, 011301 (2011)

DY 29.50 Thu 17:00 Poster A

Moving grains out of the way — •Jean-François Métayer[1], Annika Döring[1], Mario Scheel[2], and Matthias Schröter[1] — [1]Max Planck Institute for Dynamics and Self-organization, Göttingen, Germany — [2]European Synchrotron Radiation Facility Beamline ID15, Grenoble, France

A recent study on slowly sheared granular media [1] found that the fluctuations of the shear stress could be used to measure the elastic response of the granular medium.

Continuing this study, we made tomographies of a slowly sheared granular bed at ESRF synchrotron in Grenoble. Using particle tracking we were able to access the length of the shear zone, which is necessary to compute elastic moduli of the granular medium. We also visualized the local reorganisation of grains while the bed is sheared. These quantities are presented as a function of the initial packing fraction (before the bed is sheared) and allow more insight in the measurements shown in [1].

[1] J-F. Métayer, D. Suntrup, C. Radin, H. Swinney, and M. Schröter, EPL 93 (2011) 64003

DY 29.51 Thu 17:00 Poster A

Kontaktmodelle mit Zeitverfestigung und numerische Fließortmessung — •Alexander Weuster und Dietrich E. Wolf — Fakultät für Physik und CeNIDE, Universität Duisburg-Essen

Das Fließverhalten von Schüttgütern kann sich mit zunehmender Lagerungszeit verändern. Dieses Phänomen tritt im Alltag z.B. bei Zucker auf, der unter etwas erhöhter Luftfeuchtigkeit gelagert wird: Obwohl er sich zunächst unproblematisch in einen Behälter füllen lässt, bildet sich nach wenigen Tagen Lagerungszeit eine zumindest partiell verbackene Struktur. Mikroskopisch betrachtet bilden sich Festkörperbrücken zwischen den einzelnen Partikeln, die aus dem Partikelmaterial selbst bestehen. Aber auch auskristallierende Fremdpartikel aus einer die Partikel umgebenden Lösung, biologische, oder chemische Prozesse können zu einer zeitlichen Zunahme der Haftkraft im Schüttgut oder Pulver führen.

Wir möchten ein viskoelastisches- und ein elasto-plastisches Kontaktmodell vorstellen, das diese Zeitverfestigung berücksichtigt. Ausgangspunkt ist hierbei die Annahme, dass sich innerhalb einer charakteristischen Zeit (t_c) eine gewisse Haftkraft zwischen den Partikeln aufbaut. Ist t_c klein, spricht man von einem „adhäsionsbestimmten“ Kontakt. Ein großes t_c entspricht hingegen einem „zementierungsbestimmten“ Kontakt. In diesem Fall bilden sich Kristallisationsbrücken zwischen den Partikeln. Die Auswirkungen dieser mikromechanischen Eigenschaft auf das makroskopische Fließverhalten des Pulvers soll anhand von Computersimulationen des Fließorts diskutiert werden.

DY 29.52 Thu 17:00 Poster A

Measuring the configurational temperature in a binary disc packing — •Song-Chuan Zhao and Matthias Schröter — Max-Planck-Institute for Dynamics and Self-Organization, Göttingen,Germany

A statistic mechanics of granular packing has been suggested by analogy to thermodynamic systems [1]. A configurational temperature, called compactivity, is defined as $\partial V/\partial S$. The measurement of the compactivity plays an important role in testing the validity of this theory. A method to measure X is suggested as following: if the Volume probability distribution is Boltzmann like, then the ratio of two overlapping distributions at different configurational temperatures should be exponential. An extension of this method can be used to measure the entropy in a granular packing. McNamara and coworkers apply this method to sphere packing and conclude that the distribution of Voronoi volumes obeys the theoretical prediction [2].

Recently we have found that there are correlations between Voronoi volumes in disc packing [3]. These correlations raise the question on which scale a configurational temperature can be defined uniformly. We present the compactivity measurement of a bi-disperse disc system and show that the compactivity is uniform above a certain scale.

[1] S.F. Edwards and R.B.S. Oakeshott, Physica A, 157 1080 (1989)
[2] Sean McNamara, Patrick Richard, Sbastien Kiesgen de Richter, Grand Le Car and Renaud Delannay, Phys. Rev. E, 80 031301 (2009)
[3] Song-Chuan Zhao, Stacy Sidle, Harry L. Swinney and Matthias Schröter, arXiv:1109.0935

DY 29.53 Thu 17:00 Poster A

multiple shear band formation in granular materials — robabeh moosavi[1], •reza shaebani[2], maniya maleki[1], janos torok[2], and dietrich wolf[2] — [1]Department of Physics, Institute for Advanced Studies in Basic Sciences (IASBS), Zanjan 45137-66731, Iran — [2]Department of Theoretical Physics, University of Duisburg-Essen, 47048 Duisburg, Germany

We present numerical and experimental evidences for multiple shear band formation in sheared granular materials. A modified Couette cell with a split bottom near the outer cylinder is made rough by gluing glass beads on all boundaries. The cell is filled with the same beads and sheared by slowly rotating the inner cylinder and the attached bottom disk. A wide shear band is mostly observed at the free surface of the material. However, depending on the filling height and grain size, simultaneous shear bands may form near the confining walls and in the middle of the system. By minimizing the rate of energy dissipation, we numerically find similar velocity profiles for intermediate filling heights and relatively large grain sizes.

DY 29.54 Thu 17:00 Poster A

Dynamics of an Intruder in Dense Granular Fluids — •Matthias Grob, Andrea Fiege, and Annette Zippelius — Institut für Theoretische Physik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

We investigate the dynamics of an intruder pulled by a constant force in a dense two-dimensional granular fluid by means of event-driven molecular dynamics simulations. We show how a propagating momentum front develops and compactifies the system when reflected by the boundaries. We then add a frictional force acting on each particle, proportional to the particle's velocity. Frictional motion in an event-driven simulation is implemented which allows us to carry out extensive numerical simulations aiming at the dependence of the intruder's velocity on packing fraction and pulling force. We identify a linear relation for small and a nonlinear regime for high pulling forces.

DY 30: Networks IV (with SOE)

Time: Friday 10:00–12:00 Location: MA 001

DY 30.1 Fri 10:00 MA 001

k-shells on weighted networks — •Antonios Garas[1], Frank Schweitzer[1], and Shlomo Havlin[2] — [1]Chair of Systems Design ETH Zurich, Kreuzplatz 5, CH-8032 Zurich — [2]Minerva Center and Department of Physics, Bar-Ilan University, 52900 Ramat Gan, Israel

We discuss the decomposition of networks using k-shells in order to rank the nodes according to their centrality. We introduce a generalized method that considers the link weights in the calculation of k-shells. Our method is directly applicable to weighted networks, without the need of any arbitrary threshold on the weight values, and we show that it is able to partition a network in a more refined way, in comparison with the unweighted case. Using the classic SIR model, we show that nodes with higher spreading potential are located into shells closer to the core, and subsequently, we we discuss applications in different systems ranging from economic networks to on-line communities.

DY 30.2 Fri 10:15 MA 001

All scale-free networks are sparse — •Charo Del Genio[1], Thilo Gross[1], and Kevin Bassler[2,3] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Deutschland — [2]University of Houston, Houston, TX, USA — [3]Texas Center for Superconductivity, Houston, TX, USA

We study the realizability of scale free-networks with a given degree sequence, showing that the fraction of realizable sequences undergoes two first-order transitions at the values 0 and 2 of the power-law exponent. We substantiate this finding by analytical reasoning and by a numerical method, proposed here, based on extreme value arguments, which can be applied to any given degree distribution. Our results reveal a fundamental reason why large scale-free networks without constraints on minimum and maximum degree must be sparse.

DY 30.3 Fri 10:30 MA 001

Information storage, loop motifs and clustered structure in complex networks — •Joseph T. Lizier, Fatihcan M. Atay, and Jürgen Jost — Max Planck Institute for Mathematics in the Sciences, Inselstrasse 22, 04103 Leipzig, Germany

Information storage is a key operation in distributed computation, and an important analytic tool for understanding dynamics on, and information processing capabilities of, complex networks. We use a standard discrete-time linear Gaussian model to analyze information storage capability of individual nodes in complex networks, given network structure and link weights. In particular, we investigate the role of two and three-node motifs in contributing to information storage, and express information storage analytically in terms of the contributions of these motifs. We show analytically that directed feedback loops and feedforward loop motifs are the dominant contributors to information storage capability. Crucially, where the network contains positive edge weights on average, the information storage capability is positively correlated to the counts of these motifs. We also show the direct relationship between clustering coefficient(s) and information storage which results from these expressions. These results explain the dynamical importance of clustered structure, and offer an explanation for the prevalence of these motifs in biological and artificial networks.

DY 30.4 Fri 10:45 MA 001

Statistical description of subgraph fluctuations in random graphs — •Christoph Fretter[1], Matthias Müller-Hannemann[2], and Marc-Thorsten Hütt[1] — [1]School of Engineering and Science, Jacobs University, Bremen, Germany — [2]Institut für Informatik, Martin-Luther Universität Halle-Wittenberg, Germany

The pattern of over- and under-representations of three-node subgraphs has become a standard method of characterizing complex networks and evaluating, how this intermediate level of organization contributes to network function. We explored this relationship in previous publications [1,2]. Understanding statistical properties of subgraph counts in random graphs, their fluctuations and their interdependencies with other topological attributes is an important prerequisite for such investigations. Here we introduce a formalism for predicting subgraph fluctuations induced by perturbations of uni-directional and bidirectional edge densities. On this basis we predict the over- and under-representation of subgraphs arising from a density mismatch between a network and the corresponding pool of randomized graphs serving as null model. Such mismatches occur for example in modular and hierarchical graphs.

[1] Krumov L., Fretter, C., Müller-Hannemann, M., Weihe, K. and Hütt, M.-Th., Motifs in co-authorship networks and their relation to the impact of scientific publications. Eur. Phys. J. B, (2011) in press. [2] Marr, C., Theis, F.J., Liebovitch, L.S. and Hütt, M.-Th., Patterns of subnet usage in the transcriptional regulatory network of Escherichia coli. PLoS Computational Biology 6, e1000836 (2010).

DY 30.5 Fri 11:00 MA 001

Impact of boundaries on fully connected random geometric networks — Justin Coon[1], Carl Dettmann[2], and •Orestis Georgiou[3] — [1]Toshiba Telecommunications Research Laboratory, Bristol, UK — [2]School of Mathematics, University of Bristol, Bristol, UK — [3]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

Many complex networks exhibit a percolation transition involving a macroscopic connected component, with universal features largely independent of the microscopic model and the macroscopic domain geometry. In contrast, it turns out that the transition to full connectivity is strongly influenced by the details of the boundary and exhibit an alternative form of universality. The statistical physics approach taken produces a generalized formula for the probability of fully connectivity. This result is largely model independent and facilitates system design to promote or avoid full connectivity for diverse geometries in arbitrary dimension. I will also discuss applications of this formula to wireless communication networks.

DY 30.6 Fri 11:15 MA 001

Self-organized critical adaptive networks — •Matthias Rybarsch and Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen, Otto-Hahn-Allee, 28359 Bremen

Dynamical systems of spins on a network can exhibit self-regulated evolution towards a critical state and are used as toy models for self-tuning in biological neural networks [1]. If, however, the model is changed from spin type to a network composed of Boolean state nodes which are more plausible in the biological context [2], this rewiring algorithm will no longer evolve the system to criticality and cannot be directly transferred in a simple way. Also, the function of such self-organized networks is often limited to a certain network topology like a regular lattice in case of ref. [1]. Here, we discuss a correlation-dependent mechanism for self-organized connectivity evolution which adresses these difficulties and evolves a biologically motivated, yet minimalistic network model to an average connectivity close to criticality in terms of damage spreading, both on lattice or random network topology.

[1] S. Bornholdt and T. Roehl: Self-organized critical neural networks, Phys. Rev. E 67, 066118 (2003)

[2] M. Rybarsch and S. Bornholdt: On the dangers of Boolean networks: Activity dependent criticality and threshold networks not faithful to biology, arXiv:1012.3287 (2010)

DY 30.7 Fri 11:30 MA 001

Continuous Percolation by Discontinuities — •Jan Nagler — MPI DS, Göttingen

The extent to which a complex network is connected crucially impacts its dynamics and function. Percolation, the transition to extensive connectedness on gradual addition of links, is often used to describe and model many different types of structure in the real world. How single links may *explosively* change macroscopic connectivity in networks where links add competitively according to certain rules has been debated extensively in the past three years. In the very recent article [Science **333**, 322 (2011)], O. Riordan and L. Warnke state that (i) *any rule based on picking a fixed number of random vertices gives a continuous transition*, and (ii) that *explosive percolation is continuous.* It is equally true that certain percolation processes based on picking a fixed number of random vertices are discontinuous. Here we resolve this apparent paradox. We identify and analyze this by studying an extremal case of a process that is continuous in the sense of Riordan and Warnke but still exhibits infinitely many discontinuous jumps in an arbitrary vicinity of the transition point. We demonstrate analytically that continuity at the transition and discontinuity of the percolation process are compatible for certain competitive percolation systems.

DY 30.8 Fri 11:45 MA 001

The role of nonlocal coupling in the transition from coherent to incoherent states — •Bruno Riemenschneider[1], Iryna Omelchenko[1,2], Philipp Hövel[1,2], Yuri Maistrenko[3,4], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin — [2]Bernstein Center for Computational Neuroscience, Humboldt-Universität zu Berlin — [3]Institute of Mathematics, National Academy of Sciences of Ukraine — [4]National Center for Medical and Biotechnical Research, National Academy of Sciences of Ukraine

We investigate the spatio-temporal dynamics of coupled chaotic systems with nonlocal interactions, where each element is coupled to a fixed number of nearest neighbours. Characteristic examples of such networks appear in neuroscience, chemical oscillators, electrochemical systems, and Josephson junctions. Depending upon the coupling parameters, i.e., strength and range, we find variations in temporal behaviour, as well as characteristic spatial patterns. These include wave-like solutions and a transition from spatial coherence to incoherence. Partially coherent, chimera-like states represent the characteristic spatio-temporal patterns at the transition, which leads to spatial chaos. The systems have been analyzed by both numerical simulations and theoretical derivations. To demonstrate the universality of our findings, we consider time-discrete as well as time-continuous models, i.e., logistic maps, Rössler and Lorenz systems, respectively. For each system we choose parameters that lead to chaotic behaviour in the uncoupled case.

DY 31: Phase Transitions and Critical Phenomena

Time: Friday 9:30–13:30 Location: MA 004

Topical Talk DY 31.1 Fri 9:30 MA 004

Pair Superfluidity of Constrained Bosons in Two Dimensions — •Stefan Wessel[1] and Lars Bonnes[2] — [1]RWTH Aachen University, Germany — [2]University of Innsbruck, Austria

Bose gases with attractive interactions can form two different superfluid phases. Besides the conventional (atomic) superfluid, a molecular superfluid of boson pairs can form, with exhibits half-vortex topological defects. To prevent the attractive Bose gas from collapse, a scenario has been recently been proposed, where the particles are constrained to an optical lattice and furthermore subject to strong three-body losses, that project out triple occupancy on each lattice site. Employing quantum Monte Carlo simulations, we study the quantum phase transition between these atomic and dimer superfluids. Evidence is provided for the existence of a tricritical point along the saturation transition line, where the transition changes from being first-order to a continuous transition of the dilute bose gas of holes. We show that the thermal disintegration of the pair superfluidity is governed by the proliferation of fractional half-vortices leading to an Berezinskii-Kosterlitz-Thousless transition with an anomalous stiffness jump. In addition to the (conventional) Berezinskii-Kosterlitz-Thousless transition out of the atomic superfluid, we furthermore identify a direct thermal phase transition separating the pair and the atomic superfluid phases, and show that this transition is continuous with critical scaling exponents consistent with those of the two-dimensional Ising universality class.

DY 31.2 Fri 10:00 MA 004

Loop percolation — •Matthias J. F. Hoffmann, Susan Nachtrab, Gerd E. Schröder-Turk, and Klaus Mecke — Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen

We report a new planar percolation model, called *loop percolation*, which is in a different universality class than the conventional bond- or site percolation models. The model is defined by randomly disconnecting, with probability p, the degree-four nodes of a planar square lattice into two unconnected degree-two nodes; for each disconnection, the two possible orientations are chosen randomly with the probability $x = 1/2$. The extremal configurations are the periodic square lattice (at $p = 0$ with no disconnected nodes) and a configuration of many self-avoiding unbranched random walks, "spaghetti state", when all nodes are disconnected at $p = 1$. Numerical analysis shows that this model has a percolation transition at $p_c = 1$, that is, only when all nodes are disconnected. The critical exponents ($\beta = 1/3$, $\nu = 4/3$, $\gamma = 67/36$, $D_f = 79/48$) of this transition are numerically shown to be significantly different from those of the conventional bond- or site-percolation model, and to agree with a mapping to the six-vertex model. Further, when suitably generalized to $x \neq 1/2$ the model shows a percolation transition at $p_c = (1 + |2x - 1|)^{-1}$ with the critical bond/site percolation exponents for all $x \neq 1/2$.

DY 31.3 Fri 10:15 MA 004

Mean-field behavior of the negative-weight percolation model on random regular graphs — •Oliver Melchert[1], Alexander K. Hartmann[1], and Marc Mezard[2] — [1]Institut für Physik, Universität Oldenburg (Germany) — [2]Laboratoire de Physique Théorique et Modeles Statistiques, Université de Paris Sud (France)

In the presented study, we investigate the critical properties of minimum-weight loops and paths in the negative-weight percolation (NWP) problem on 3-regular random graphs (RRGs), i.e. graphs where each node has exactly 3 neighbors and were there is no regular lattice structure [1]. By studying a particular model on RRGs, one has direct access to the mean-field exponents that govern the model for $d > d_u$. The presented study aims to support the previous conjecture $d_u = 6$ [2] by directly computing the mean field exponents for the NWP model with a bimodal weight distribution, and comparing them to those found for a regular hypercubic lattice with dimension $d = 6$. The presented results are obtained via computer simulations, using an appropriate mapping to a matching problem, as well as by analytic means, using the replica symmetric cavity method for a related polymer problem. We find that the numerical values for the critical exponents on RRGs agree with those found for $d = 6$-dimensional hypercubic lattice graphs within errorbars and hence support the conjectured upper critical dimension $d_u = 6$.

[1] OM, A.K. Hartmann, and M. Mézard, PRE 84, 041106 (2011)
[2] OM, L. Apolo, and A.K. Hartmann, PRE 81, 051108 (2010)

DY 31.4 Fri 10:30 MA 004

The two-dimensional Ising spin glass at zero temperature — •Hamid Khoshbakht[1], Martin Weigel[1,2], and Jacob D. Stevenson[3] — [1]Institut für Physik, Johannes Gutenberg-Universitaät Mainz, D-55099 Minz, Germany — [2]Applied Mathematics Research Center, Coventry University, Coventry, CV1 5FB, UK — [3]University Chemical Laboratories, Lensfield Road, Cambridge, CB2 1EW, UK

Ground states for the Ising spin glass in two dimensions can be determined in polynomial time as long as periodic boundary conditions are applied at most in one direction. Using a recently proposed mapping to an auxiliary graph decorated with Kasteleyn cities, we determine ground states for systems with open-periodic boundary conditions for lattices of linear sizes up to $L = 9000$ and calculate defect energies as well as domain-wall lengths. Although the matching approach does not work for periodic-periodic boundaries, where less finite-size corrections are expected, using a windowing technique allows to determine quasi-exact ground-states for lattices up to $L = 3000$. By using these techniques, we arrive at high-precision estimates of the spin-stiffness exponent and the domain-wall fractal dimension for Gaussian as well as bimodal couplings. We compare the geometry of the thus generated domain walls with the detailed predictions given for random curves in the plane in the framework of Schramm-Loewner Evolution (SLE).

DY 31.5 Fri 10:45 MA 004

One-dimensional Vector Spin Glasses with Long-Range interactions — •Frank Beyer[1] and Martin Weigel[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, 55099 Mainz, Germany — [2]Applied Mathematics Research Centre, Coventry University, Coventry, CV1 5FB, England

One-dimensional spin-glass models with power-law interactions allow for numerically tackling large linear system sizes. At the same time tuning the interaction range enables to study systems with zero-temperature transitions, with non-trivial finite-temperature transitions and in the mean-field regime, respectively. Here, we focus on the case of vector spin glasses with an infinite number of spin components which shows some important differences as compared to models with a finite number of components. Using extensive numerical calculations at zero and finite temperatures, we determine the phase diagram of the model and elucidate its critical behavior in the mentioned regimes.

DY 31.6 Fri 11:00 MA 004

Isotropic-polar phase transitions in an amphiphilic fluid — Michael Melle[1], Stefano Giura[1], Sergej Schlotthauer[1], and •Martin Schoen[1,2] — [1]Stranski-Lab. f. Physikalische und Theoretische Chemie, Technische Universität Berlin, Straße des 17. Juni 115, 10623 Berlin, Germany — [2]Dept. of Chemical and Biomolecular Engineering, North Carolina State University, 911 Partners Way, Raleigh, NC 27695, USA

We present Monte Carlo simulations of the isotropic-polar (IP) phase transition in an amphiphilic fluid carried out in the isothermal-isobaric ensemble. Our model consists of Lennard-Jones spheres where the attractive part of the potential is modified by an orientation-dependent function. This function gives rise to an angle dependence of the intermolecular attractions corresponding to that characteristic of point dipoles. Our data show a substantial system-size dependence of the dipolar order parameter. We analyze the system-size dependence in terms of the order-parameter distribution and a cumulant involving its first and second moments. The order parameter, its distribution, and susceptibility observe the scaling behavior characteristic of the 3D-Ising universality class. Because of this scaling behavior and because all cumulants have a common intersection irrespective of system size we conclude that the IP phase transition is continuous. Considering pressures $1.3 \leq P \leq 3.0$ we demonstrate that a line of continuous phase transition exists which is analogous to the Curie line in systems exhibiting a ferroelectric transition. Our results are qualitatively consistent with Landau's theory of continuous phase transitions.

DY 31.7 Fri 11:15 MA 004

Dynamical quantum phase transitions for quenches in the transverse field Ising model — •Markus Heyl[1], Anatoli Polkovnikov[2], and Stefan Kehrein[1] — [1]Department of Physics, Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München — [2]Department of Physics, Boston University

We study quenches of the magnetic field in the transverse field Ising model. For quenches across the quantum critical point, the boundary partition function in the complex temperature-time-plane shows lines of Fisher zeros that intersect the time axis, indicating non-analytic real-time evolution in the thermodynamic limit (analogous to well-known thermodynamic phase transitions). We characterize these dynamical quantum phase transitions through topological quantum numbers and show that the dynamic behavior generates a new emergent non-equilibrium energy scale. We argue that this behavior is expected to be generic for interaction quenches across quantum critical points in other models as well.

15 min. break

DY 31.8 Fri 11:45 MA 004

Properties of stable and metastable crystals and interfaces in the hard sphere system — •Mohammad Hossein Yamani and Martin Oettel — Institute of Physics, Johannes Gutenberg University, Mainz, Germany

Colloidal hard spheres are an intensely studied model system for addressing the nucleation problem. Understanding homogeneous and heterogeneous nucleation requires a precise knowledge about equilibrium crystal structures, crystal-liquid surface tensions and interface tensions with substrates. Density Functional Theory (DFT) as one of the core theoretical approaches of statistical physics of fluids and crystals, is able to treat such an important system successfully and accurately. We use density functional theory of fundamental measure type (FMT) to obtain the fully minimized periodic FCC crystal profiles and wall-liquid interface tensions and compare to new, accurate simulation data. Furthermore we present first DFT results obtained by unconstrained minimization for free energies of metastable BCC and HCP crystals. DFT results in the case of FCC compare very well to simulation results. HCP and FCC differ only in the stacking sequence of hexagonally packed planes of particles, and thus one expects only a small free-energy difference between these two structures. We present preliminary results obtained by FMT for the differences between FCC and HCP in free-energy and in the unit cell density distribution.

DY 31.9 Fri 12:00 MA 004

On phase-field modeling with a highly anisotropic interfacial energy — •Michael Fleck, Leslie Mushongera, Denis Pilipenko, Kumar Ankit, and Heike Emmerich — Materials and Process Simulation, University of Bayreuth, Germany

The crystalline nature of solids results in the anisotropy of many thermophysical parameters. In particular, the interfacial energy between different phases is often found to be a function of the crystallographic orientation of the interface. We report on phase-field approaches that allow for anisotropies sufficiently high so that the interface develops facets as well as sharp corners due to missing crystallographic orientations. The latter implies the necessity of a regularization that enforces local equilibrium at the corners, to remove the ill-posednes of the phase field evolution equation. Two different anisotropic phase-field formulations are presented and discussed: The classical model that allows the interface to vary with orientation, and another more recent formulation that has a constant interface width. Further, we develop an explicit finite difference scheme that combines a two-step differentiation with a stagnation grid formulation. The presented numerical implementation is stable and accurate enough to account for odd crystal symmetries and high angle rotations of the initial crystalline orientation. Even in the case of highly anisotropic interfacial energies, both formulations show excellent agreement with the well-known Wulff construction of the equilibrium shape of a particle embedded in a matrix.

DY 31.10 Fri 12:15 MA 004

Improved Linear Programming applied to the Vertex Cover Problem — •Timo Dewenter and Alexander K. Hartmann — Institut für Physik, Universität Oldenburg, 26111 Oldenburg

We consider the well studied [1] NP-complete Vertex Cover problem (VC) on Erdős-Rényi (ER) random graphs with finite connectivity c.

Previously, we applied the mapping of VC to a Linear Programming problem (LP), where the nodes of the graph are represented by real-valued variables $x_i \in [0, 1]$. A value of $x_i = 0$ means that the node is uncovered and $x_i = 1$ denotes a covered node. Each edge $\{j, k\}$ in the graph is related to a constraint $x_j + x_k \geq 1$ in the LP. The Simplex-algorithm is then applied to solve this LP, but for larger c incomplete solutions with variables $x_i \in]0, 1[$ are found. So we used a cutting-plane approach that adds constraints to the LP based on loops in the graph with odd length leading typically to exact solutions for $c < e \approx 2.718$.

Here, we solve small subgraphs $G_S = (U, E_U)$ with an exact algorithm and add contraints $\sum_{x_i \in U} \geq |V_C(G_S)|$ to the LP, where $|V_C(G_S)|$ is the size of the minimum VC of G_S. This leads in principle to complete solutions, but here we only use $|U| \leq 10$. The behaviour of this algorithm is studied for ER random graphs as a function of c. After performing statistical analyses [2] for different system sizes, we compare with the phase diagram for the critical fraction x_c of covered vertices.

[1] M. Weigt and A.K. Hartmann, Phys. Rev. Lett. **84**, 26 (2000)
[2] A.K. Hartmann: *Practical Guide to Computer Simulations*, World-Scientific, 2009

DY 31.11 Fri 12:30 MA 004

Simulation of critical phenomena in fluids with the Lattice Boltzmann method — •Markus Gross and Fathollah Varnik — ICAMS, Ruhr-Universität Bochum, Germany

Recently, thermal fluctuations have been introduced into the Lattice Boltzmann method for non-ideal fluids, allowing one to numerically solve the fluctuating Navier-Stokes equations for an isothermal liquid-vapor system. Here, it is demonstrated that the method, employing a Ginzburg-Landau free energy functional, correctly reproduces the static critical behavior associated with the Ising universality class. A particular focus will be on finite-size effects and issues related to the global conservation of the order-parameter. Additionally, the critical behavior of the transport coefficients (speed of sound, shear and bulk viscosity) of the model, which describes an isothermal compressible fluid, is discussed.

DY 31.12 Fri 12:45 MA 004

Numerical study of polymer adsorption on a fractal substrate — Viktoria Blavatska[1,2] and •Wolfhard Janke[1] — [1]Institut für Theoretische Physik, Universität Leipzig, Germany — [2]Institute for Condensed Matter Physics, National Academy of Sciences of Ukraine, Lviv, Ukraine

We study the adsorption of flexible polymer macromolecules on a percolation cluster, formed by a regular two-dimensional disordered lattice at critical concentration p_c of attractive sites. The percolation cluster is characterized by a fractal dimension $d_s^{p_c} = 91/49$. The conformational properties of polymer chains grafted to such a fractal substrate are studied by means of the pruned-enriched Rosenbluth method (PERM). We find estimates for the surface crossover exponent governing the scaling of the adsorption energy in the vicinity of the transition point, $\phi_s^{p_c} = 0.425 \pm 0.009$, and for the adsorption transition temperature, $T_A^{p_c} = 2.64 \pm 0.02$. As expected, the adsorption is diminished when the fractal dimension of the substrate is smaller than that of a plain Euclidean surface. The universal size and shape characteristics of a typical spatial conformation which attains a polymer chain in the adsorbed state are analyzed as well.

Topical Talk DY 31.13 Fri 13:00 MA 004

Multifractal fluctuations and Scaling at the three-dimensional Anderson transition — •Alberto Rodriguez[1,2], Louella J. Vasquez[3], Keith Slevin[4], and Rudolf A. Roemer[2] — [1]Phisikalisches Institut, Albert-Ludwigs Universität Freiburg, 79104, Freiburg, Germany — [2]Department of Physics and Centre for Scientific Computing, University of Warwick, Coventry, CV4 7AL, UK — [3]Institute of Advanced Study, Complexity Science Centre and Department of Statistics, University of Warwick, Coventry, CV4 7AL, UK — [4]Department of Physics, Osaka University, 1-1 Machikaneyama, Toyonaka, Osaka 560-0043, Japan

We analyze the multifractal properties of the critical wavefunctions at the disorder-induced three-dimensional metal-insulator transition (MIT), and we discuss the relation between the multifractal spectrum and the probability density function (PDF) of wavefunction intensities at criticality. A new PDF-based characterization of the MIT is presented and emphasized in connection with latest experimental observations of critical phenomena. Furthermore, we describe a new multifractal finite size scaling (MFSS) procedure that permits the simultaneous estimation of the critical parameters and the multifractal exponents. Simulations of system sizes up to $L^3 = 120^3$ and involving nearly 10^6 independent wavefunctions have yielded unprecedented precision for the critical disorder $W_c = 16.530(16.524, 16.536)$ and the critical exponent $\nu = 1.590(1.579, 1.602)$. This formalism is applicable to any continuous phase transition exhibiting multifractal fluctuations in the vicinity of the critical point.

DY 32: Soft Matter II

Time: Friday 10:00–12:30 Location: MA 144

DY 32.1 Fri 10:00 MA 144

Deformation of Platonic foam cells: Effect on growth rate — •Myfanwy Evans[1], Johannes Zirkelbach[1], Gerd Schröder-Turk[1], Andrew Kraynik[1,2], and Klaus Mecke[1] — [1]Theoretische Physik, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany — [2]Manchester, UK

Coarsening is the process by which gas diffuses through the films that separate foam cells, and causes them to grow or shrink over time. The growth rate for 2D foams is fully described by von Neumann's law, and relies solely on cell topology. The situation for 3D foams is poorly understood, despite claims to the contrary, where growth rate depends on that cell shape as well as topology. Isotropic Plateau polyhedra (IPP) are hypothetical 3D foam cells, composed of F regular spherical-capped faces, that fulfill Plateau's laws and enable an analytical solution for the growth rate in terms of F.

We use the Surface Evolver to model the deformation of Platonic foam cells that are suspended from wire frames. The deformed cells satisfy Plateau's laws when subjected to compression, extension, shear and torsion. For all three Platonic foams, which are the realisable IPP, we observe different responses in the growth rate to deformation, depending on cell type, deformation mode and frame size. The growth rate can increase or decrease with increasing cell distortions: in the case of pentagonal dodecahedron cells subjected to torsion, even the direction of diffusion can change. Our analysis of the relation between cell deformation and growth rate offers insight into the coarsening of real foams, where cells are not necessarily regular and isotropic.

DY 32.2 Fri 10:15 MA 144

Colloid crystallization on strained substrates — •Stefan Frieder Hopp[1], Andreas Heuer[1], John Savage[2], and Itai Cohen[3] — [1]Institut für Physikalische Chemie, Universität Münster, 48149 Münster, Germany — [2]Liquidia Technologies, Research Triangle Park, North Carolina 27709, USA — [3]Department of Physics, Cornell University, Ithaca, New York 14853, USA

The crystallization behavior of charge-stabilized polystyrene colloids on a colloidal monolayer [1] is modeled by kinetic Monte Carlo simulations. In this context, the local properties of particles in simply shaped colloid clusters are studied as a function of substrate strain due to lattice mismatch. The colloidal depletion interaction is described by a short-range Morse potential. It is shown the experimental data for isotropically strained square lattices can be reproduced. Putting the focus on a particular intermediate strain, the behavior of the colloid crystals is examined with regard to the dependence on temperature. Remarkably, one observes the crystals melt with decreasing temperature, contrary to general expectation. Based on a particle dimer, this is explained by the interplay of energy and entropy both of which show a distinct dependence on the height of the particles as well as the particle-particle distance.

[1] R. Ganapathy, M. R. Buckley, S. J. Gerbode, I. Cohen, Science, 327, 445 (2010).

DY 32.3 Fri 10:30 MA 144

Gravitational-like collapse in a petri dish: shock waves in the capillary compactification of a colloidal patch — •Johannes Bleibel[1,2], Siegfried Dietrich[1,2], Alvaro Dominguez[3], and Martin Oettel[4] — [1]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany — [2]Institut für theoretische und angewandte Physik, Universität Stuttgart, Stuttgart, Germany — [3]Física Teórica, Universidad de Sevilla, Sevilla, Spain — [4]Institut für Physik, WA 331, Johannes Gutenberg Universität Mainz, Mainz, Germany

Interfacially trapped, micrometer-sized colloidal particles interact via long-ranged capillary attraction which is analogous to two-dimensional screened Newtonian gravity with the capillary length λ as the tunable screening length. Using Brownian dynamics simulations, density functional theory, and analytical perturbation theory, we study the dynamics of a finitely-sized patch of colloids. Whereas the limit $\lambda \to \infty$ corresponds to the global collapse of a self-gravitating fluid, for intermediate λ we predict theoretically and observe in simulations a ring-like density peak at the outer rim of the disclike patch, moving as an inbound shock wave [1]. For smaller l the dynamics crosses over to spinodal decomposition showing a coarsening of regions of enhanced density which emerge from initial fluctuations [1,2]. The influence of hydrodynamic interactions on this capillary collapse will be discussed.

[1] J. Bleibel, A. Domínguez, S. Dietrich, and M. Oettel, Phys. Rev. Lett. 107, 128302 (2011).

[2] J. Bleibel, A. Domínguez, M. Oettel, and S. Dietrich, Eur. Phys. J. E 34, 125 (2011).

DY 32.4 Fri 10:45 MA 144

Influence of Striped Surface-Inhomogeneities on the Conformations of a Single Self-Interacting Polymer near an Attractive Substrate — •Monika Möddel[1], Wolfhard Janke[1], and Michael Bachmann[2] — [1]Institut für Theoretische Physik, Universität Leipzig — [2]Center for Simulational Physics, The University of Georgia, Athens, GA 30602, U.S.A.

Specific interaction between a polymer and a solid substrate is a key ingredient of the problem of how the polymer can recognize a target surface with a specific pattern. The statistics of homopolymer adsorption onto homogeneously attractive substrates has been studied quite extensively in the past. In our own recent studies [1,2], we investigated thermal fluctuations of energetic and structural quantities to identify a variety of pseudophases of a semiflexible off-lattice homopolymer for a range of different surface attraction strengths and temperatures and complemented this by a microcanonical analysis. By slowly "switching on" a striped surface potential we now study how this conformational behavior is modified and the collapse, freezing, adsorption and surface-recognition of an individual chain are related. The width of the stripe is also varied to some extent since it turns out to have a considerable influence. Shape anisotropy is discussed as well. In all cases studied, the adsorption and the recognition are found to be well-separated. The data are obtained by parallel tempering Monte Carlo simulations.

[1] M. Möddel, M. Bachmann, and W. Janke, J. Phys. Chem. B **113**, 3314 (2009); [2] M. Möddel, W. Janke, and M. Bachmann, Phys. Chem. Chem. Phys. **12**, 11548 (2010); Macromolecules, **44**, 9013 (2011).

DY 32.5 Fri 11:00 MA 144

Bifurcations of films of binary liquid mixtures on a solid substrate and with a free surface — Fathi Bribesh[1], •Santiago Madruga[2], and Uwe Thiele[1] — [1]Department of Mathematical Sciences, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK — [2]ETSI Aeronauticos, Universidad Politécnica de Madrid, 28040 Madrid, Spain

Model-H is used to describe the phase separation of a free surface film of a binary liquid mixture on a horizontal solid homogeneous substrate [see e.g., U. Thiele, S. Madruga and L. Frastia, *Phys. Fluids* **19**, 122106 (2007)]. We consider the incompressible and isothermal case. The spatial distribution of the two components of the mixture is characterised by the local difference in concentrations. The upper surface of the film (liquid-gas interface) is free to move and characterised by the film thickness profile. The present study focuses on (i) the linear stability (in time) of steady stratified (layered) critical films and (2) fully two-dimensional steady states characterised by their concentration profiles and film thickness profiles for the critical (mean concentration equals zero) and off-critical (mean concentration does not equal zero) cases. The bifurcation structure is determined for various steady states employing as control parameter the lateral domain size and mean concentration for the critical and off-critical case respectively. Thereby the mean film thickness and the energetic bias at the free surface (corresponding to a linear Marangoni effect) are fixed at several particular values.

We acknowledge support by the EU (PITN-GA-2008-214919).

DY 32.6 Fri 11:15 MA 144

Soft tetramer model for diblock copolymers — •Thomas Michael and Wolfgang Paul — Institut für Physik, Martin-Luther-Universität, 06099 Halle

Analytical results for a soft-particle model for diblock copolymers are presented. The tetramer model consists of a soft dumbbell for each block. The overall four beads interact by an effective soft-particle pair-potential. The interaction length is finite. The analytical calculations result in a phase diagram of the melt depending on the composition of the diblock copolymer and the temperature. The corresponding collective structure factor of the polymer melt is calculated in RPA. The compressible and incompressible case is discussed and the results are compared to Monte-Carlo simulations [1] based on the same model and to experiments.

[1] C. Gross and W.Paul, Soft Matter, **6**, 3273 (2010)

DY 32.7 Fri 11:30 MA 144

Charged Colloids under Gravity — •Erdal Celal Oğuz[1], René Messina[2], and Hartmut Löwen[1] — [1]Institut für Theoretische Physik II: Weiche Materie, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany — [2]Laboratoire de Chimie et Physique - Approche Multi-Echelle des Milieux Complexes, Université de Lorraine, Institut de Chimie, Physique et Matériaux (ICPM), 1 Bld Arago, 57078 Metz - Cedex 3, France

In the ongoing presentation we report the structural solid-solid transitions of purely repulsive colloidal particles under gravity. We perform Monte Carlo simulations, where the constitutive particles are governed by the Yukawa pair interaction and the colloids are initially confined onto a hard planar surface by the gravity. For sufficiently high gravitational strengths particles are arranged in a riangular monolayer lattice. Reducing the gravitational strength leads to more layers of the same symmetry but less particle density, a superlattice respectively. Thus, our model enables a controlled layering mechanism. Furthermore, theoretical predictions are proposed to characterize the monolayer-multilayer transitions.

DY 32.8 Fri 11:45 MA 144

Freezing behavior of parallel hard spherocubes — Matthieu Marechal, •Urs Zimmermann, and Hartmut Löwen — Institut für Theoretische Physik II, Heinrich-Heine-Universität Düsseldorf, Universitätstraße 1, 40225 Düsseldorf, Germany

The monocomponent fluid of parallel hard cubes exhibits a continuous freezing transition, whereas hard spheres possess a first order freezing transition. We introduce the model of parallel hard spherocubes, a class of colloidal shapes characterized by the cube parameter q that describes the continuous deformation from parallel hard cubes ($q = 1$) to hard spheres ($q = 0$). The extended-deconvolution fundamental measure theory is used as well as Monte Carlo and event-driven Molecular Dynamics simulations to determine the phase boundaries. The qualitative change from continuous freezing to first order freezing is analyzed with respect to the shape of the spherocubes. The continuous freezing is found to be persistence for cubes with finite rounding ($q < 1$). We present a phase diagram of packing fraction and the cube parameter q, discuss deviations between theory and simulations and observe an anomalous high vacancy concentration ($> 10\%$) in the solid phase. Furthermore a new stable crystalline structure corresponding to a sheared simple cubic phase is found.

DY 32.9 Fri 12:00 MA 144

Randomly Charged Polymers in Porous Environments — Viktoria Blavatska[1] and •Christian von Ferber[2,3] — [1]Institute for Condensed Matter Physics, NAS Ukraine, UA-79011 Lviv — [2]Applied Mathematics Research Centre, Coventry University, Coventry, UK — [3]Theoretische Polymerphysik, Universitat Freiburg, 79104 Freiburg

Macromolecules in solution as they are encountered in chemical and biological physics may often be described as long flexible chains. Their conformations are strongly influenced by monomer-monomer interactions. In the absence of other interactions the excluded volume interaction governs the behaviour in the long chain limit. Here, however we we consider the influence of two additional effects namely positive or negative charges along the chain (as observed e.g. for peptides) and secondly a disordered environment that displays long range correlations (that decay with a power law). Both of these long range effects induce additional interactions. We discuss in detail the interplay between these three interactions and determine the situations in which they may govern the conformational behaviour of the polymer.

DY 32.10 Fri 12:15 MA 144

Nonlocal effective average action approach to crystalline phantom membranes — •Nils Hasselmann[1] und Fabio L. Braghin[2] — [1]MPI f. Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart — [2]Instituto de Fisica, UFG, Goiania, Brazil

We investigate the properties of crystalline phantom membranes, at the crumpling transition and in the flat phase, using a nonperturbative renormalization group approach. We avoid a derivative expansion of the effective average action and instead analyse the full momentum dependence of the elastic coupling functions. This leads to a more accurate determination of the critical exponents and further yields the full momentum dependence of the correlation functions of the in-plane and out-of-plane fluctuation. The flow equations are solved numerically for $D = 2$ dimensional membranes embedded in a $d = 3$ dimensional space. Within our approach we find a crumpling transition of second order which is characterized by an anomalous exponent $\eta_c \approx 0.63(8)$ and the thermal exponent $\nu \approx 0.69$. Near the crumpling transition the order parameter of the flat phase vanishes with a critical exponent $\beta \approx 0.22$. The flat phase anomalous dimension is $\eta_f \approx 0.85$ and the Poisson's ratio inside the flat phase is found to be $\sigma_f \approx -1/3$. At the crumpling transition we find a much larger negative value of the Poisson's ratio $\sigma_c \approx -0.71(5)$. We discuss further in detail the different regimes of the momentum dependent fluctuations, both in the flat phase and in the vicinity of the crumpling transition, and extract the crossover momentum scales which separate them.