STRUCTURE FORMATION AND SELF-ORGANIZATION IN NON-EQUILIBRIUM SYSTEMS (SYSS)

Jointly organized by
Dynamics and Statistical Physics (DY)
Physics of socio-economic Systems (AKSOE)

Walter Zimmermann
Theoretische Physik Ia
Universität Bayreuth
walter.zimmermann@uni-bayreuth.de

Andreas Schadschneider
Theoretische Physik
Universität Köln
as@thp.uni-koeln.de

OVERVIEW OF INVITED TALKS AND SESSIONS

(lecture rooms BAR Schö, HSZ 04, P1)

Invited Talks

SYSS 4.1	Fri	10:15	(HSZ 04)	**Experiments on structure formation in complex continua**, Ingo Rehberg, Christof Krülle, Reinhard Richter, Wolfgang Schöpf
SYSS 4.2	Fri	10:45	(HSZ 04)	**Coarsening versus lengthscale persistence in nonequilibrium pattern-forming systems**, Chaouqi Misbah, Paolo Politi
SYSS 4.3	Fri	11:15	(HSZ 04)	**Spatio-temporal chaos and defects in pattern-forming systems**, H. Riecke
SYSS 4.4	Fri	11:45	(HSZ 04)	**Self-organization and collective decision making in animal societies**, Jean-Louis Deneubourg
SYSS 4.5	Fri	12:15	(HSZ 04)	**Time-delayed feedback control of noise-induced patterns** , Eckehard Schöll, Alexander Balanov, Johanne Hizanidis, Grischa Stegemann

Sessions

SYSS 1	**Structure Formation and Self-Organization in non-equilibrium Systems I**	Thu 09:30–13:00	BAR Schö	SYSS 1.1–1.13
SYSS 2	**Structure Formation and Self-Organization in non-equilibrium Systems II**	Thu 14:30–16:00	BAR Schö	SYSS 2.1–2.6
SYSS 3	**Structure Formation and Self-Organization in non-equilibrium Systems - Poster**	Thu 16:00–18:00	P1	SYSS 3.1–3.26
SYSS 4	**Structure Formation and Self-Organization in non-equilibrium Systems III**	Fri 10:15–12:45	HSZ 04	SYSS 4.1–4.5

Sessions

– Invited, Contributed Talks and Posters –

SYSS 1 Structure Formation and Self-Organization in non-equilibrium Systems I

Time: Thursday 09:30–13:00 Room: BAR Schö

SYSS 1.1 Thu 09:30 BAR Schö

Ferrosolitons — •Reinhard Richter[1] and Igor Barashenkov[2] — [1]Experimentalphysik 5, Universität Bayreuth, D-95440 Bayreuth, Germany — [2]University of Capetown, Rondebosch 7700, South Africa

Solitary structures in two dimensions have been mostly confined to vortices in superconductors and superfluids on one hand and dissipative solitons in nonequilibrium systems on the other. While the stability of the former is due to their nontrivial topology, the latter are believed to be stable thanks to the balance of strong dissipation and energy gain. Neither of these stabilisation principles could be at work for localised patterns on the surface of a horizontal layer of ferrofluid: this is a lossless system with no special topology. Nevertheless, we have recently discovered stable solitary spikes in the bistable regime of the Rosensweig instability [1]. These *ferrosolitons* can be generated by a local magnetic field application, or simply by mechanical perturbation of the flat surface. Their stability can be explained in part by the locking of the expanding front to the wavelength of the coexisting periodic pattern [2]. We investigate the profiles of ferrosolitons, measured by means of radioscopy [3] and analyze the locked wavefront. The ferrosolitons have oscillatory tails, which become wider as the magnetic induction is increased. We compare the measured profiles with analytical and numerical estimations.

[1] Reinhard Richter, and I.V. Barashenkov, Phys. Rev. Lett. **94** 184503-1 (2005).
[2] Y. Pomeau, Physica D (Amsterdam) **23**, 3 (1986).
[3] Reinhard Richter, and Jürgen Bläsing, Rev. Sci. Instrum. **72**, 1729 (2001).

SYSS 1.2 Thu 09:45 BAR Schö

Structure Formation by Heat - understanding and applying Thermophoresis — •Stefan Duhr, Franz Weinert, and Dieter Braun — Noether Group on Dissipative Microsystems, Applied Physics, Ludwig Maximilians Universität München, Amalienstr. 54, 80799 München, Germany

Molecules typically move from hot to cold in temperature fields, a non-equilibrium effect called thermophoresis. Compared to electrophoresis, temperatures can be applied with micrometer resolution in microfluidics, yielding an alternative to electrophoresis for biomolecule analysis. Until recently, however, theoretical understanding was poor. We report on:

o Thermophoresis of DNA and polystyrene beads is driven by solvation entropy, shown by novel microfluidic fluorescence measurements.As a result, the effective charge of molecules is inferred more robust and simple than from electrophoresis.

o Nonlinear thermophoresis reveals deviations from the Onsager foundation of thermophoresis due to a breakdown of the local equilibrium assumption. Only then, thermophoresis across a solid-water interface can crystallize colloids.

o DNA is accumulated by flow in microfluidics. Giant accumulation driven by convection is predicted for single nucleotides near volcanic seafloor vents, closing missing links in molecular evolution of life

o Water can be pumped with an infrared laser scanning microscope as a result of nonlinear thermal expansion. It allows to shrink thermophoretic field flow fractionation to microfluidic dimensions.

Website: http://www.biophysik.physik.uni-muenchen.de/Braun

SYSS 1.3 Thu 10:00 BAR Schö

Competition between traveling waves of left and right spiral vortices and their combinations with different or equal amplitudes — •Alexander Pinter, Manfred Lücke, and Christian Hoffmann — Institut für Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken, Germany

Stability, bifurcation properties, and the spatiotemporal behavior of different nonlinear combination structures of spiral vortices in the counter rotating Taylor-Couette system are investigated by full numerical simulations and by coupled amplitude equation approximations. Stable cross-spiral structures with continuously varying content of left and right spiral modes are found. They provide a stability transferring connection between the initially stable, axially counter propagating wave states of pure spirals and the axially standing waves of so-called ribbons that become stable slightly further away from onset of vortex flow.

SYSS 1.4 Thu 10:15 BAR Schö

Hexaroll chaos in inclined layer convection — •Will Brunner[1], Jonathan McCoy[2], Werner Pesch[3], and Eberhard Bodenschatz[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Goettingen — [2]LASSP, Department of Physics, Cornell University — [3]Physikalisches Institut, Universitaet Bayreuth

We present results from experiments in thermal convection with the aim of studying defect mediated turbulence. We induce a defect turbulent state by tilting non-Boussinesq convection 5 degrees from horizontal. This breaks the symmetry of the hexagonal pattern, producing a pattern that resembles hexarolls found in cylindrical rotating convection. We find a new type of defect complexes in addition to the expected penta-hepta defects (PHDs), where a dislocation of one sign is found in one hexagonal mode and one of opposite sign is nearby in another mode. These new defect complexes, which we term same-mode complexes (SMCs) consist of two dislocations of opposite sign in the same mode. SMCs can self-annihilate, unlike PHDs which can only annihilate pairwise. This self-annihilation gives rise to a term in the annihilation rate law that is proportional to the number of defects present. We conclude that mass action is a robust concept for dealing with reaction rates in defect turbulence, and propose that SMCs may be present in other systems where an anomalous linear annihilation rate is seen.

SYSS 1.5 Thu 10:30 BAR Schö

Bénard–convection in colloidal suspensions — •Björn Huke and Manfred Lücke — Institute for theoretical physics, Saarland University, D-66041 Saarbrücken

Colloidal suspensions differ from molecular binary mixtures like, e.g., ethanol-water by the fact that the solutal diffusion time scales are several orders of magnitudes longer: The Lewis number of the former is typically of the order of 10^{-3} to 10^{-4}. In addition they can also exhibit a Soret effect that is several orders of magnitude stronger leading to separation ratios of the order of 100.

We numerically studied the convection in a such a fluid layer heated from below for these parameters using the Galerkin method. We calculated bifurcation diagrams for roll, square, and crossroll patterns that are known to exist as stable form of convection in molecular mixtures with positive separation ratios. The stability region of these structures was investigated for selected parameter combinations. Oscillatory crossrolls and their transition into the square and stationary crossroll state were studied via a time integration of the mode equations.

Traveling waves that are an important structures in molecular fluids with negative separation ratio were also studied and found to play no role in colloids at moderate heating rates.

— 15 min. break —

SYSS 1.6 Thu 11:00 BAR Schö

Gas-Enrichment at Liquid-Wall Interfaces — •Stephan M. Dammer and Detlef Lohse — University of Twente, Physics of Fluids

Molecular dynamics simulations are performed to study the effects of dissolved gas on liquid-wall interfaces. The systems are composed of different particle species (liquid/gas/wall) that interact via Lennard-Jones potentials. Liquid-gas mixtures in contact with walls exhibit gas enrichment at the walls, which increases with increasing hydrophobicity, quan-

tified by the contact angle which is obtained from additional simulations of droplets at walls. When compared to the gas concentration in the bulk of the liquid, for atomically smooth hydrophobic walls the observed gas enrichment can exceed more than two orders of magnitude. In the case of nanometric wall roughness gas accumulates in nano-crevices on hydrophobic walls. Close to the walls the liquid shows a layered structure which is less pronounced for increasing contact angle and which for large contact angle is considerably altered by the presence of a gas. Furthermore, we investigate the influence of the gas enrichment at hydrophobic walls on dynamical properties, such as the slip length, by nonequilibrium molecular dynamics simulations.

SYSS 1.7 Thu 11:15 BAR Schö

Xenon Dendrites: Onset and Amplitude of Sidebranches — •Oliver Wittwer and Jörg Bilgram — Laboratorium für Festkörperphysik, ETH, CH 8093 Zürich, Switzerland

The initiation of sidebranches of three dimensional xenon dendrites has been studied. The sidebranches of dendrites growing in a steady state are initiated by selective amplification of thermal noise in the region of the dendrite tip. Measurements of the amplitudes of sidebranches as a function of the distance behind the tip have been compared with theoretical predictions for non-axisymmetric needle cystals [1]. Noise initiated sidebranches start to grow 3-7 tip radii behind the tip. The sidebranches growing at the four fins are not correlated and the amplitudes measured in our experiments are in quantitative agreement with the theoretical predictions.

We have also found a second type of sidebranch initiation: External perturbations lead to sidebranches starting to grow directly at the tip. They are highly correlated at the four fins and their amplitudes are higher than the ones of noise initiated sidebranches.

[1] E. Brener, Phys. Rev. Lett. **71**, 3653 (1993)

SYSS 1.8 Thu 11:30 BAR Schö

Self-Organized Electrochemical Assembly of Mesoscale Silver Wires and Dendrites — •Sheng Zhong[1,2], Thomas Koch[1,2], Harald Roesner[2], Horst Hahn[2], Eberhard Nold[3], Dong Wang[4], Mu Wang[5], Stefan Walheim[2], and Thomas Schimmel[1,2] — [1]Institute of Applied Physics, University of Karlsruhe, D-76128 Karlsruhe, Germany — [2]Institute of Nanotechnology (INT), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [3]Institute for Materials Research I (IMF I), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [4]Institute for Materials Research II (IMF II), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [5]National Laboratory of Solid-State Microstructures, Nanjing University, Nanjing 21009, China

Mesoscopic metal structures attract considerable attention due to their potential application in next-generation electronic devices, such as interconnects and active components. The synthesis of these mesoscale building blocks is a crucial step towards the implementation of nanodevices. We demonstrate a novel and simple electrochemical deposition approach for the self-assembly of free-standing single-crystalline mesoscopic silver wires and regular dendritic structures from an aqueous solution without templates, additives and surfactants. The single-crystalline silver wires and structures grow spontaneously under a direct current electric field. Wire diameters down to 100 nm and wire lengths up to 150 micro meter and more are found. This simple electrodeposition system using a growth process that can be observed in situ also opens a convenient way to study the electrochemical growth mechanism in order to tailor mesostructures on this length scale.

SYSS 1.9 Thu 11:45 BAR Schö

Pattern formation in the CO + O reaction on Ir(111) surfaces under the influence of noise — •Stefan Wehner[1], Patrick Hofmann[2], Dieter Schmeisser[2], Helmut R. Brand[3], and Jürgen Küppers[1,4] — [1]Experimentalphysik III, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Angewandte Physik II, Brandenburgische Technische Universität Cottbus, 03013 Cottbus, Germany — [3]Theoretische Physik III, Universität Bayreuth, 95440 Bayreuth, Germany — [4]Max-Planck-Institut für Plasmaphysik (EURATOM Association), 85748 Garching, Germany

The rate of CO oxidation on Ir(111) surfaces exhibits bistability at $T = 500$ K in a range of the CO fraction Y in the CO + O reactant gas flux. Quadrupol mass spectrometer measurements of the CO_2 rates as a function of the noise strength imposed on Y are well reproduced by parameter-free modeling.

We present Photoelectron emission microscopy (PEEM) measurements and 2D calculations of the spatio-temporal patterns of CO and O rich domains. The role of combined multiplicative and additive noise on Y for CO and O domain wall motion and island nucleation-growth-coalescence processes is analysed.

For small noise amplitudes few islands nucleate and grow up to some 100 μm in diameter, before they merge with another island. With increasing noise amplitudes more islands nucleate. With large noise amplitudes bursts to and switching between the branches is observed. The domain wall velocity is found to be independent of the noise strength and island size.

SYSS 1.10 Thu 12:00 BAR Schö

Spatio-temporal dynamics of a fuel cell reaction system: New oscillatory mechanism, bifurcation analysis and efficiency improvement — •Nilüfer Baba[1], Jan Siegmeier[1], Antoine Bonnefont[2], and Katharina Krischer[1] — [1]Physik Department, E19, Technische Universität München, James Franck Str. 1, D - 85748 Garching bei München, Germany — [2]Laboratoire d'Electrochimie et de Chimie Physique du Corps Solide, UMR - Université Louis Pasteur - C.N.R.S. 4, rue Blaise Pascal, 67000 Strasbourg, France

Fuel cells are promising energy conversion devices and much research effort is focussed on their improvement. One considerable problem is that the fuel gas (hydrogen) is contaminated by CO when produced from methane which constitutes the main H_2 source. CO acts as a poison since it absorbs on the Pt catalyst, blocks hydrogen oxidation and reduces the efficiency.

We present a mathematical model for the $H_2/CO/Pt$ system and its bifurcation analysis. We demonstrate that the system displays a novel type of oscillations, involving a slow chemical autocatalysis of surface adsorbed species and a fast negative feedback loop involving the electric potential. The latter, however, is switched off in the presence of a high poison coverage, which enables potentiostatic oscillations in a wide parameter range. Simulations also show Turing patterns of small wavelengths. Based on these results we discuss control techniques that stabilize the system in a state where the coverage is minimized and thus the efficiency is enhanced.

SYSS 1.11 Thu 12:15 BAR Schö

Pulse propagation in excitable media at the edge to oscillatory kinetics. — •Grigori Bordiougov, Georg Roeder, and Harald Engel — Institut fuer Theoretische Physik, TU Berlin, Hardenbergstr. 36 10623 Berlin

Small amplitude oscillations in the wake of solitary pulses are shown to have a strong impact on the interaction between excitation pulses. Annihilation of colliding pulses is replaced by reflective collision. In addition to this soliton-like behavior we find bistability in the dispersion curve for periodic pulse trains [1]. Close to the Canard explosion in the local dynamics we observe break-up of the dispersion curve into disconnected branches accompanied by the formation of isolas [2]. Our results shed new light on the still open mechanism of the transition between trigger and phase waves in reaction-diffusion systems [3]. The reported behavior is generic for a whole class of media with an unique homogeneous steady state that undergoes a supercritical Hopf-bifurcation with Canard explosion due to well separated time scales (so-called type II excitable systems [4]).

1. G. Bordiougov et al., Phys. Rev. Lett. 90(14), 148302 (2003).

2. G. Roeder et al., Bistable dispersion relation in an excitable FitzHugh-Nagumo model, in preparation.

3. G. Bordiougov et al., From Trigger to Phase Waves and Back Again, submitted to Physica D.

4. E. Izhikevich, Int. J. of Bif. and Chaos 10 1171-1266 (2000).

SYSS 1.12 Thu 12:30 BAR Schö

Coherent structures in nonequilibrium wave dynamics — •Benno Rumpf[1], Guenter Radons[1], Alan Newell[2], and Laura Biven[3] — [1]Physics Institute, TU Chemnitz, 09107 Chemnitz, Germany — [2]Mathematics Department, University of Arizona, Tucson, Arizona, USA — [3]Max-Planck-Institut fuer Physik komplexer Systeme, 01187 Dresden, Germany

Turbulence of dispersive nonlinear waves transfers energy from a long spatial scale, where a driving force is applied, to a short viscous scale. In many physical systems, the wave amplitude is almost everywhere small, while strongly nonlinear structures with high amplitudes emerge intermittently. Our study of these coherent structures in nonequilibrium sys-

tems is based on a simple statistical analysis of a wide class of Hamiltonian wave equations. The formation of coherent structures depends critically on the thermodynamic parameters of the low-amplitude waves, and on the frequency of coherent structures.

[1] B.Rumpf, L.Biven, Weak turbulence in the Majda-McLaughlin-Tabak equation: Fluxes in wavenumber and in amplitude space, Physica D 204, 188-203, (2005)
[2] B.Rumpf, A.C.Newell, Intermittency as a consequence of turbulent transport in nonlinear systems, Phys.Rev.E 69, 026306, (2004)
[3] B.Rumpf, Intermittent movement of localized excitations of a nonlinear lattice, Phys.Rev.E 70, 016609 (2004)
[4] B.Rumpf, Simple statistical explanation for the localization of energy in nonlinear lattices with two conserved quantities, Phys.Rev.E 69, 016618 (2004)

SYSS 1.13 Thu 12:45 BAR Schö

Patterns in chaotically mixing fluid flows — •Arthur Straube and Arkady Pikovsky — University of Potsdam, Am Neuen Palais 10, PF 601553, D-14415 Potsdam

We consider a reaction-diffusion system of an activator-inhibitor type and impose a periodic in space mixing flow. We fix governing parameters in a way that ensures the stability of the homogeneous steady state in reaction-diffusion system, so that without advection no Turing patterns occur. Next, we increase the advection rate and study the influence of the flow on the stability of this state. One could expect that because the flow is mixing, it should stabilize the homogeneous state. However, the instability appears as the rate of advection increases beyond a certain threshold, which results in pattern formation. We apply the Bloch theory to find out the length-scale of the patterns, which generally do not coincide with the length-scale of the imposed flow. The mechanism of the instability can be understood from a reduced model; the results are explained by means of Lyapunov exponents. We report on two situations: (i) general case when both chemical species are advected and (ii) a partial case, when only one species is advected, which is relevant to biological applications.

Since the flow and reaction terms are generic for the effects investigated, we believe that the results hold for a variety of flows and chemical reactions.

SYSS 2 Structure Formation and Self-Organization in non-equilibrium Systems II

Time: Thursday 14:30–16:00 Room: BAR Schö

SYSS 2.1 Thu 14:30 BAR Schö

Reading the pattern in living cells - the Physics of Calcium signalling — •Martin Falcke — Abteilung Theorie SF5, Hahn-Meitner-Institut Berlin

Structure formation and self-organization is used inside living cells to transmit signals or to encode a physiological state as we will outline by several examples: The dynamics of periodic wave trains and wave train bifurcations explain the response of cells to energization of mitochondria or overexpression of SERCA-protein. The spatial structure of cells allows for oscillations in a non-oscillatory dynamic regime by repetitive wave nucleation. The talk gives a survey of how living cells transform structure formation far from equilibrium into physiological function.

SYSS 2.2 Thu 14:45 BAR Schö

Nonlinear competition between patterns in filament-motor-systems — •Falko Ziebert and Walter Zimmermann — Theoretische Physik Ia, Universität Bayreuth

Biopolymer systems have various mechanisms for pattern formation. One is the interplay of polymerization and demixing
[1] .

Interaction via molecular motors is a second way and modelled here by a Smoluchowski equation approach. It is shown that the homogeneous distribution of filaments, such as actin or microtubules, may become either unstable with respect to a homogeneous nematic state, to an orientational instability of a finite wave number or with respect to modulations of the filament density, where long wavelength modes are amplified as well. In the stationary case above threshold nonlinear interactions select either stripe patterns or periodic asters
[2] .

The existence and stability ranges of each pattern close to threshold are predicted in terms of a weakly nonlinear perturbation analysis and confirmed by numerical simulations of the basic model equations. Also oscillatory solutions exist and existence and stability of 1D and 2D wave solutions are discussed.

[1] F. Ziebert and W. Zimmermann, Phys. Rev. E **70**, 022902 (2004)
[2] F. Ziebert and W. Zimmermann, Europhys. J. E **18**, 41 (2005)

SYSS 2.3 Thu 15:00 BAR Schö

Scaling regimes in bundling dynamics — •Martin Zapotocky, Peter Borowski, and P. K. Mohanty — Max Planck Institut für Physik komplexer Systeme, Dresden, Germany

We discuss the dynamics of bundling in a population of interacting directed random walks. The model is meant to describe structures formed by the growing axons of peripheral neurons. To account for neural turnover, the random walks are removed and replaced at a fixed rate. Based on numerical simulations, we identify two distinct scaling regimes of the asymptotic dynamics. We investigate analytically the form of the distribution of bundle sizes and the values of growth exponents.

SYSS 2.4 Thu 15:15 BAR Schö

Non-stationary spatial pattern formation in a game-theoretical model — •Robert Mach and Frank Schweitzer — Chair of Systems Design, ETH Zurich, CH-8092 Zurich

Self-organization is a predominant dynamics also in socio-economic systems, where it results from the nonlinear interactions between spatially distributed agents. Each of these agents is driven by internal forces, for example maximizing its private utility. This depends on the interaction with other agents, which is costly. So the whole multi-agent system can only operate in non-equilibrium. The agent's interaction often also leads to the adaptation of a more successful strategy for maximizing the utility. As an example for the interaction we choose a standard example of evolutionary game theory, the iterated prisoner's dilemma (IPD), where 8 different strategies are possible. We are interested in the spatio-temporal distributions of such strategies and the relation to known dynamics of pattern formation in physical systems. We show that the survival of strategies strongly depends on the evolutionary path of the system, i.e. on local conditions. This may lead to different attractors, characterized by different pools of strategies. While the frequencies remain stable, they may still show non-stationary patterns. We further investigate the local conditions that trigger the dynamics towards these different attractors.

SYSS 2.5 Thu 15:30 BAR Schö

Traveling ion channel density waves affected by a conservation law — •Ronny Peter and Walter Zimmermann — Theoretische Physik Ia, Universität Bayreuth, D-95440 Bayreuth

A model of mobile, charged ion channels embedded in a biomembrane is investigated. The ion channels fluctuate between an opened and a closed state according to a simple two-state reaction scheme whereas the total number of ion channels is a conserved quantity. Local transport mechanisms suggest that the ion channel densities are governed by electrodiffusion-like equations that have to be supplemented by a cable-type equation describing the dynamics of the transmembrane voltage. It is shown that the homogeneous distribution of ion channels may become unstable to either a stationary or an oscillatory instability. The nonlinear behavior immediately above threshold of an oscillatory bifurcation occuring at finite wave number is analyzed in terms of amplitude equations. Due to the conservation law imposed on ion channels large-scale modes couple to the finite wave number instability and have thus to be included in the asymptotic analysis near onset of pattern formation. A modified Ginzburg-Landau equation extended by long-wavelength stationary excitations is established and it is highlighted how the global conservation law affects the stability of traveling ion channel density waves.

SYSS 2.6 Thu 15:45 BAR Schö

Travelling wave forcing of Turing structures — •Sten Rüdiger — Hahn-Meitner Institut, Abt Sf5, Glienicker Str. 100, 14109 Berlin

We study domain walls in pattern forming systems of Turing type that are externally forced by a periodic pattern, which is close to spa-

tial resonance of 2:1 (the period of the forcing being half of the internal wavelength) and moving perpendicular to the stripes. Two transitions are identified: A transition where the pattern lags behind the forcing as the forcing becomes too fast and a spontaneous symmetry-breaking transition of walls.

The departure from perfect spatial resonance renders the kink bifurcation imperfect and causes the walls to drift. We study the velocity of the kinks, which behaves strongly nonlinear close to the transitions. A phase approximation is used to analyze the behavior and is valid in a large range of parameters. Results from the phase equation can be generalized to hold for different ratios n:1.

SYSS 3 Structure Formation and Self-Organization in non-equilibrium Systems - Poster

Time: Thursday 16:00–18:00 Room: P1

SYSS 3.1 Thu 16:00 P1

Monte Carlo modelling of layers of evaporating nanoparticle suspensions: Rupture patterns and front instabilities — •Ioan Vancea[1], Christopher P. Martin[2], Matthew O. Blunt[2], Philip Moriarty[2], and Uwe Thiele[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, D-01187 Dresden, Germany — [2]School of Physics & Astronomy, The University of Nottingham, University Park, Nottingham, NG7 2RD, United Kingdom

A Monte Carlo model introduced by Rabani et al. [1] has previously been shown to simulate accurately many of the characteristics of colloidal nanoparticle monolayers deposited via evaporation from a solvent [1,2]. We have used variants of the model put forward in Ref. 1 to investigate systematically the interdependence of evaporative dewetting of the liquid and demixing of liquid and particles. Spinodal dewetting and heterogenous nucleation are analysed in their dependence on the concentration of the nanoparticles. A second focus lies on the study of the transversal instability of a straight dewetting front.

[1] E. Rabani et al., Nature **426**, 271-274 (2003).
[2] C. P. Martin et al., Nano Lett. **4**, 2389-2392 (2004).

SYSS 3.2 Thu 16:00 P1

Dendritic and fractal patterns formation in non-equilibrium solidification — •Peter Galenko and Dieter Herlach — Institut für Raumsimulation, DLR, 51170 Köln, Germany

Results of computational modeling are synthesized for the forms of crystals growing in undercooled liquid. Solidification patterns are analyzed as a result of the first-order phase transformation controlled by the heat and mass diffusion, atomic kinetics, and interfacial anisotropy. It is shown that fractal patterns are observed at a vanishing anisotropy of surface energy and atomic kinetics of the solid-liquid interface. Simulated patterns are summarized into morphological spectrum which is considered as a sequence of growth shapes that forms versus undercooling (deviation from thermodynamic equilibrium) in solidifying system. A diagram "complexity of growth forms" as a function of "microscopic disorder and deviation from equilibrium" is presented. The work was supported by DFG under contract No. He 1601/13.

SYSS 3.3 Thu 16:00 P1

Transient states during vapor treatment of thin, lamellar diblock copolymer films — •C.M. Papadakis[1], D. Posselt[2], and D.-M. Smilgies[3] — [1]Physikdepartment E13, Technische Universität München, James-Franck-Str. 1, D-85747 Garching — [2]IMFUFA, Roskilde University, Denmark — [3]Cornell University, Ithaca NY, USA

Diblock copolymers in the melt spontanously self-organize into mesoscopically ordered structures. In order to understand their response to changes of the environment, in-situ and real-time methods are of great value. We have performed time-resolved grazing-incidence small-angle X-ray scattering (GISAXS) measurements on thin films of lamellar poly(styrene-b-butadiene) diblock copolymers having initially the lamellae parallel or perpendicular to the substrate surface.

We have found that the response to toluene vapor is very different for the two lamellar orientations. Films with the perpendicular orientation reacted at once, and continuous swelling of the film occurred on the time scale of minutes. Tilting of lamellar stacks was observed as well, however, during drying, the perpendicular orientation was recovered [1]. In films with the initially parallel orientation, the lamellae swell significantly, but the lamellar interfaces remain flat. After a few minutes, undulations of the lamellar interfaces are observed, which, however, diminish again after approx. one minute, and the initial lamellar thickness is recovered. These observations point to an instability during the swelling process.

[1] D.-M. Smilgies, P. Busch, C.M. Papadakis, D. Posselt, Synchr. Rad. News 15, no. 5, S. 35 (2002).

SYSS 3.4 Thu 16:00 P1

Simulation of Liesegang Pattern Formation of Nano Particles in Glass — •Jan W. Kantelhardt — Fachbereich Physik und Zentrum für Computational Nanoscience, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany

By numerical simulations we study diffusion-reaction processes that lead to the self organized formation of Liesegang patterns of metal nano particles in glass. Liesegang patterns are a quasi-periodic structuring that occurs in diffusion limited chemical reactions with two components. Such patterns have been observed in experiments with different metal nano particles in silicate glass. We compare results for the Ostwald Prager model and for the competitive particle growth model. Based on Monte Carlo simulations with cellular automata models we study the stability of the pattern formation process as well as its possible modification by modulated external parameters, and we compare with previous mean-field results.

SYSS 3.5 Thu 16:00 P1

Controlling of structure formation in crystal growth — •Marco Fell and Jörg Bilgram — Laboratorium für Festkörperphysik, ETH, 8093 Zürich, Schweiz

In our experiments we study instabilities of both the spherical and the flat solid-liquid interfaces and apply it in a controlled manner to obtain symmetric crystals. Xenon dendrites growing in steady-state from pure melt show a characteristic spacing between the side branches, depending on undercooling. The interface instability of the Mullins-Sekerka type leads to side branches. The growth velocity and the temporal development of a branch can significantly differ from a branch on the opposite side of the dendrite. The interaction between adjacent branches on all sides cancels out a specific number of them but it is not predictable which will be retained. In this sense such a steady state dendrite is 'statistical symmetric'. By an external perturbation we can influence the branching of the growing tip. i) A single short-time heating pulse of the melt initiates synchronously side branches in all growth directions. Statistical processes govern their further development as the system relaxes to the steady-state behavior some seconds after the pulse. ii) Stabilizing the temperature of the melt above the melting temperature for some minutes leads to melting and to a reduced curvature of the solid-liquid interface. A sharp temperature drop restarts growth and initiates new side branches growing symmetrically on four sides with contours remaining in good correlation for the time it takes the crystal to grow some ten tip radii. They even seem to interact over a macroscopic distance of more than 50 tip radii (about 1 mm).

SYSS 3.6 Thu 16:00 P1

Excitation symmetries and existence of subharmonic response of electroconvection patterns — •Jana Heuer and Ralf Stannarius — Institut für experimentelle Physik, Otto-von-Guericke-Universität Magdeburg

In electrohydrodynamic convection (EHC), surprising fundamentally new phenomena are still discovered, that contribute to general understanding of pattern dynamics in spatially extended dissipative systems. The excitation of this system with sine or square waves of period T leads to convection structures in which the dynamic variables (charge density, director and velocity fields) perform T-periodic oscillations. Nonconventional wave forms like sawtooth excitation can lead to patterns with T-periodic as well as T-antiperiodic (subharmonic) dynamics. We consider different classes of excitation wave forms $E(t)$: such with antisymmetry in the two half periods, $E(t) = -E(t + T/2)$, such with time inversion symmetry, $E(t) = E(-t)$, and dichotomous wave forms (two alternating values, E_1, E_2) and discuss their influence on the pattern dynamics. From the Floquet analysis of linear differential equations that describe the system near threshold, we show analytically that each

of these conditions inhibits subharmonic dynamics at onset. Numerical and experimental support of these predictions is provided.

By some generalization, other dynamic systems can be characterized by equally simple ODEs. Therefore we propose general conclusions about the relations between the time symmetry of the excitation field and the dynamic response of the system.

SYSS 3.7 Thu 16:00 P1

Surface roughening and self-organized criticality: the influence of quenched disorder. — •Christof Aegerter[1], Marco Welling[2], and Rinke Wijngaarden[2] — [1]Fachbereich Physik Universität Konstanz; Universitätstrasse 10; 78457 Konstanz — [2]Vrije Universiteit; De Boelelan 1081; 1081HV Amsterdam, The Netherlands

Self-organized criticality (SOC) has attracted considerable interest due to its possible wide ranging impliations on broad range of subjects. However the experimental observation of SOC using stringent criteria has been difficult and the question of the critical parameters to observe SOC remans open. When SOC is observed, it often goes together with the appearance of a rough surface, indicating the importance of quenched disorder in the appearance of SOC. Here we study magnetic vortices penetrating a type-II superconductor in the presence of varying quenched disorder by introducing Hydrogen impurities. This problem can be mapped onto that of a growing pile of sand. The roughness properties of the vortex landscape and the avalanche size distribution are compared for different amounts of disorder. We find that (i) a minimal amount of quenched disorder is necessary to observe SOC and (ii) that the presence of a rough surface by itself cannot be used as a sufficient criterion for the observation of self-organized criticality.

SYSS 3.8 Thu 16:00 P1

Interplay between thermodynamics and kinetics in the capping of InAs/GaAs(001) quantum dots — •Paola Acosta — Max-Planck-Institute for Solid State Research

Three-dimensional islands grown by Stranski-Krastanov heteroepitaxy have been the subject of an intensive study over the last decade. In order to be employed as quantum dots (QDs) these islands must be overgrown with a wider energy band gap material. The capping typically produces strong changes in their morphology and composition, determining the final QD optoelectronic properties. A clear understanding of this process is therefore of fundamental importance. We have thoroughly analyzed the GaAs overgrowth of InAs self-organized islands by means of in-situ STM, as well as, ex-situ AFM. The most evident result is that two well-defined capping regimes can be distinguished. The first is characterized by a rapid partial dissolution of the pristine islands, and is governed by a fast dynamics (diffusion on strained regions, alloying, low energy facets). As a consequence in this regime the morphological transformations are almost independent of the cap deposition rate and the resulting morphologies are close to thermodynamic equilibrium. The second regime is marked by a true overgrowth of the remaining structures, and is essentially controlled by atomic diffusion processes.

SYSS 3.9 Thu 16:00 P1

Pattern Formation in the Visual Cortex: Breaking Permutation Symmetry — •Lars Reichl, Matthias Kaschube, and Fred Wolf — Max-Planck-Institut für Dynamik und Selbstorganisation, Bunsenstrasse 10, D- 37073 Göttingen and Bernstein Center for Computational Neuroscience Göttingen

Neurons in the visual cortex are selective to the orientation of a stimulus. Neighboring neurons tend to have similar orientation preferences except at singularities (pinwheel centers) around which all orientations are represented. These properties are captured in a two dimensional orientation preference map (OPM). The formation of such an OPM can be modeled by a Swift-Hohenberg equation including local and nonlocal cubic interaction terms [1]. These interaction terms possess a permutation symmetry which implies that in the leading order of a perturbative expansion there is a set of attractors (planforms) which are energetically degenerate. The pinwheel density varies across different planform solutions. We show that due to higher order corrections planforms with the lowest pinwheel density also have the lowest energy. However OPM with such low pinwheel densities have not been observed experimentally. Therefore we introduce a cubic interaction term that breaks the permutation symmetry and thus energetically favors a planform already at leading order. We use a gradient interaction that selects planforms with a high pinwheel density. In a large parameter range these planforms are preferred even if higher order corrections are considered.

[1] F. Wolf, Les Houches Lecture Notes 2005

SYSS 3.10 Thu 16:00 P1

H-theorem for interacting systems driven by multiplicative noise — •Fabian Senf and Ulrich Behn — Institut für Theoretische Physik, Universität Leipzig, POB 100 920, 04009 Leipzig

The H-theorem for a system of N globally coupled Stratonovich models is found and the convergence to the stationary solution independent of the initial distribution is proved. Due to the multiplicative noise and the interaction between the particles there is no detailled balance and therefore an analytical expression for the stationary distribution is not easily found.

Nevertheless, the information contained in the system of coupled Langevin equations provides important hints to the qualitative structure of the stationary state. The state space of the stochastic motion is divided in sectors whose topology depends on the system parameters. The Langevin flow between these sectors can be determined.

For large times the system is found with probability one in one of those sectors which have their boundary flows pointing inward, only. These are the ergodic components. This result is independent of the system size so that phase transistions associated with the breaking of ergodicity exist already for finite N. The critical exponent characterizing the order parameter near the critical point depends on all parameters of the Stratonovich model including the system size N if the latter is finite, for $N \to \infty$ see [1].

[1] T. Birner, K. Lippert, R. Müller, A. Kühnel, U. Behn, Critical behavior of nonequilibrium phase transitions to magnetically ordered states, Phys. Rev. E **65**, 046110 (2002)

SYSS 3.11 Thu 16:00 P1

Driving convection by a temperature gradient or a heat current — •Pascal Matura and Manfred Lücke — Institut für Theoretische Physik, Universität des Saarlandes, D-66041 Saarbrücken, Germany

Bifurcation properties, stability behavior, dynamics, and the heat transfer of convection structures in a horizontal fluid layer that is driven away from thermal equilibrium by imposing a vertical temperature difference are compared with those resulting from imposing a heat current. In particular oscillatory convection that occurs in binary fluid mixtures in the form of travelling and standing waves is determined numerically for the two different driving mechanisms. Conditions are elucidated under which current driven convection is stable while temperature driven convection is unstable.

SYSS 3.12 Thu 16:00 P1

Creation of the reactive microstructured surfaces — •Viatcheslav Gruzdev, Anton Kiriy, Volodymyr Senkovskyy, and Manfred Stamm — Liebniz Institute of Polymer Research Dresden, Hohe Str. 6, D-10069 Dresden, Germany

Deposition of polymers on solid surfaces allows the complete modification of the physico-chemical characteristic of a surface. Depending on the nature of the polymer deposited, it is possible to control such surface properties as hydrophilicity, hydrophobicity, adhesion and lubrication, biocompatibility and others [1]. In some applications it is also desirable to pattern polymer layers. Tuning the morphology of a surface and chemical structure is an effective way for creation of membranes, catalysts supports, cell culture media, antireflection coatings.

Here, we describe the simple patterning method, which is based on spontaneous dewetting of thin poly(glycidylmethacrylate) (PGMA) film. This polymer is well known as an universal coupling agent [2]. It was found that PGMA spincoated from different solutions may form homogeneous PGMA layer or undergoes dewetting and forms porous, chainlike or patched layers of PGMA. Type and size of the structures depends on concentration of PGMA and thermodynamic properties of the solvent and can be predicted. Obtained structures were amplified to the patterned polymer layers by grafting of the carboxy-terminated homopolymers.

\Zitat{1}{Minko, S.; Karl, A.; Senkovskyy, V.; Pomper, T.; Wilke, W. Polymer Bull., 1998, 41, 247-252} \Zitat{2}{Iyer S.K.; Zdyrko,B.; Malz, H.; Pionteck, J.; Luzinov, I Macromolecules 2000, 33, 1043-1048}

SYSS 3.13 Thu 16:00 P1

Meandering instability of a scroll wave in a chemical excitable medium — •Chaiya Luengviriya[1], Ulrich Storb[1], Gert Lindner[2], Markus Bär[2,3], and Stefan C. Müller[1] — [1]Institute for Experimental Physics, Otto-von-Guericke University Magdeburg, Germany — [2]Department for Mathematical Modelling and Data Analysis, PTB, Berlin — [3]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

Spiral waves are a characteristic feature of dynamic structure formation in nonequilibrium systems. Until now, most studies on the meandering of such spirals have been performed in two-dimensional (2D) systems. We present an experimental work about meandering of such wave dynamics in the three-dimensional (3D) case rationalized by numerical simulations.

We studied experimentally a scroll wave in the excitable Belousov-Zhabotinsky reaction by optical tomography. Therefore a scroll wave with a straight untwisted filament was initiated in the 3D experiment and observed in the course of time. This initial wave structure turned out to be unstable. After an intermediate exhibition of uniform twist, the filament took an oscillating zig-zag shaped state. For comparison with the behavior of a 2D spiral in the same medium we evaluated the wave period and the dynamics of the organizing centers (spiral tip for 2D and filament for 3D case). It turned out that this 2D spiral, if it exhibits the same period as the scroll wave in the 3D case, rotated rigidly.

The experimental findings were corrobated by 3D numerical simulations with the Barkley model suggesting that the observed filament behavior was caused by the 3D variant of the meandering instability.

SYSS 3.14 Thu 16:00 P1

Hydrodynamic instabilities in the iodate-arsenous acid reaction — •Lenka Šebestíková, Marcus J. B. Hauser, and Stefan C. Müller — University Magdeburg, Institute of Experimental Physics, Universitaetsplatz 2, 39106 Magdeburg

The splitting of fingers of propagating fronts in the arsenous acid-iodate reaction placed in a vertical Hele-Shaw cell is found to be driven by liquid flow induced by density differences in the gravitational field. The ascending thin reaction front separates the heavier reaction solution from the lighter reacted mixture. During the early stages, the finger structure of the reaction front is formed. As the fingers grow vertically and horizontally, some of them dominate and some annihilate. Correspondingly, the profile of the induced flow that is associated with the fingers is changed. We discuss how the finger splitting is related to the curvature of the reaction front and the adjacent flow field.

SYSS 3.15 Thu 16:00 P1

Spiral vortices traveling between two rotating defects in the Taylor-Couette system — •Christian Hoffmann — Institut für Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken

We present numerical calculations of vortex flows in Taylor-Couette systems with counter-rotating cylinders. The full, time dependent Navier-Stokes equations are solved with a combination of a finite difference and a Galerkin method. Systems of several cylinder lengths are simulated. They are closed by nonrotating lids. These rigid ends produce localized Ekman vortices in their vicinity and that prevent axial phase propagation of spiral vortices. Existence and spatio temporal properties of rotating defects, of modulated Ekman vortices, and of the spiral vortex structures in the bulk are presented in quantitative detail.

SYSS 3.16 Thu 16:00 P1

Traveling wave fronts and localized traveling wave convection in binary fluid mixtures — •Dominik Jung and Manfred Luecke — Institut für Theoretische Physik, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken, Germany

Nonlinear fronts between spatially extended traveling wave convection (TW) and quiescent fluid and spatially localized traveling waves (LTWs) are investigated in quantitative detail in the bistable regime of binary fluid mixtures heated from below. A finite-difference method is used to solve the full hydrodynamic field equations in a vertical cross section of the layer perpendicular to the convection roll axes. Results are presented for ethanol-water parameters with several strongly negative separation ratios where TW solutions bifurcate subcritically. Fronts and LTWs are compared with each other and similarities and differences are elucidated. Phase propagation out of the quiescent fluid into the convective structure entails a unique selection of the latter while fronts and interfaces where the phase moves into the quiescent state behave differently. Interpretations of various experimental observations are suggested.

[1] D. Jung and M. Lücke, Phys. Rev. E **71**, 026307 (2005)

SYSS 3.17 Thu 16:00 P1

The Effect of an Axial Flow on Spiral Vortices and Taylor Vortices — •Christian Hoffmann — Institut für Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken

We present numerical simulations of vortices that appear via primary bifurcations out of the unstructured circular Couette flow in the Taylor-Couette system with counter- and co-rotating cylinders. The full Navier-Stokes equations are solved with a combination of a finite difference and a Galerkin method for fixed axial periodicity lengths of the vortex patterns as well as for finite systems with rigid nonrotating lids. Differences in structure, dynamics, symmetry properties, bifurcation and stability behavior between spiral vortices and Taylor vortices are discussed in quantitative detail and compared to experimental spiral data. Furthermore, we analyze how the above properties are changed by an externally imposed axial through-flow. In particular we investigate when left handed or right handed spirals or toroidally closed Taylor vortices are preferred.

SYSS 3.18 Thu 16:00 P1

Investigation of Structure and Stability of Electrochemically Produced Mesoscale Silver Wires and Dendrites — •Thomas Koch[1,2], Sheng Zhong[1,2], Harald Roesner[2], Horst Hahn[2], Eberhard Nold[3], Dong Wang[4], Mu Wang[5], Stefan Walheim[2], and Thomas Schimmel[1,2] — [1]Institute of Applied Physics, University of Karlsruhe, D-76128 Karlsruhe, Germany — [2]Institute of Nanotechnology (INT), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [3]Institute for Materials Research I (IMF I), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [4]Institute for Materials Research II (IMF II), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany — [5]National Laboratory of Solid-State Microstructures, Nanjing University, Nanjing 21009, China

Silver mesostructures in particular have been in the focus of research due to the special properties of silver such as the highest electrical or thermal conductivity. Here we present the investigation of the structure, composition and time stability of thin mesoscale silver wires and dendrites, which were produced by a novel and simple electrochemical deposition approach. For the analysis Scanning Electron Microscopy, Transmission Electron Microscopy and Scanning Auger Micro Spectrometry were used. The wire diameters range down to 100 nm and the wire lengths up to 150 μm and more. The obtained structures are single-crystalline and stable under ambient conditions for several months. Thus these structures are of interest for application e.g. in micro electronics.

SYSS 3.19 Thu 16:00 P1

Delay of Disorder by Diluted Polymers — •Christian Wagner — Institut fuer Experimentalphysik, Universitaet des Saarlandes, D-66123 Saarbrücken

We study the effect of diluted flexible polymers on a disordered capillary wave state. The waves are generated at an interface of a dyed water sugar solution and a low viscous silicon oil. This allows for a quantitative measurement of the spatio-temporal Fourier spectrum. The primary pattern after the first bifurcation from the flat interface are squares. With increasing driving strength one observes a melting of the square pattern. It is replaced by a weak turbulent cascade. The addition of a small amount of polymers to the water layer does not affect the critical acceleration but shifts the disorder transition to higher driving strengths and the short wave length - high frequency fluctuations are suppressed.

SYSS 3.20 Thu 16:00 P1

Coherent structures and energy fluxes in amplitude space in turbulent wave dynamics — •Benno Rumpf[1], Guenter Radons[1], Alan Newell[2], and Laura Biven[3] — [1]Physics Institute, TU Chemnitz, 09107 Chemnitz, Germany — [2]Mathematics Department, University of Arizona, Tucson, Arizona, USA — [3]Max-Planck-Institut fuer Physik komplexer Systeme, 01187 Dresden, Germany

High-amplitude structures emerge intermittently from a background of low-amplitude disordered waves in nonequilibrium wave dynamics where a driving force is applied on long spatial scales, and damping at a short viscous scale. It is shown that the coherent structures cause an energy flux in amplitude space, while weakly interacting low-amplitude waves lead to an energy flux in wavenumber space.

[1] B.Rumpf, L.Biven, Weak turbulence in the Majda-McLaughlin-Tabak equation: Fluxes in wavenumber and in amplitude space, Physica D 204, 188-203, (2005)

[2] B.Rumpf, A.C.Newell, Intermittency as a consequence of turbulent transport in nonlinear systems, Phys.Rev.E 69, 026306, (2004)

SYSS 3.21 Thu 16:00 P1

Spatially localized stationary convection in binary mixtures with weakly negative Soret effect — •Dominik Jung and Manfred Luecke — Institut für Theoretische Physik, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken, Germany

The convective behaviour of a binary fluid layer (e. g. ethanol-water) heated from below has been simulated numerically for realistic boundary conditions. Because of the negative Soret effect ethanol migrates to the colder regions in a temperature gradient. The corresponding influence on buoyancy distribution makes a wide range of convection structures possible.

We found spatially localized patches of stationary overturning convection rolls (LSOC) which are stably surrounded by quiescent fluid. LSOCs can coexist at the same heating with spatially periodic stationary overturning convection (SOC), extended waves of travelling rolls (TW) and localized traveling waves (LTW). Furthermore they coexist in two basic symmetry types as well as with different roll numbers.

We identify the localization mechanism of LSOCs to be an advective redistribution of the ethanol concentration. The connection of LSOCs to standing and moving convection fronts is investigated.

SYSS 3.22 Thu 16:00 P1

Thermal expansion of niobium dichalcogenide in the vicinity of low-temperature phase transitions — •Vladimir Ibulaev, Victor Eremenko, Valentyna Sirenko, and Mikhail Shvedun — Institute for Low Temperature Physics, 61103 Kharkov, Ukraine

X-ray and dilatometric measurements were performed on charge-density-wave superconductor $2H$-$NbSe_2$ in the temperature range 1.5÷300 K. Anomalies of thermal expansion in the vicinity of CDW (32.5K) and superconducting (7.2K) transitions are discussed regarding structure evolution.

SYSS 3.23 Thu 16:00 P1

Stripe–hexagon competition in forced pattern forming systems with broken up-down symmetry — •Jochen Bammert and Walter Zimmermann — Theoretische Physik Ia, Universität Bayreuth, D-95440 Bayreuth

We investigate the response of two-dimensional pattern forming systems with a broken up–down symmetry, such as chemical reactions, to spatially resonant forcing and propose related experiments. The nonlinear behavior immediately above threshold is analyzed in terms of amplitude equations suggested for a 1 : 2 and 1 : 1 ratio between the wavelength of the spatial periodic forcing and the wavelength of the pattern of the respective system. Both sets of coupled amplitude equations are derived by a perturbative method from the Lengyel-Epstein model describing a chemical reaction showing Turing patterns, which gives us the opportunity to relate the generic response scenarios to a specific pattern forming system. The nonlinear competition between stripe patterns and distorted hexagons is explored and their range of existence, stability and coexistence is determined. Whereas without modulations hexagonal patterns are always preferred near onset of pattern formation, single mode solutions (stripes) are favored close to threshold for modulation amplitudes beyond some critical value. Hence distorted hexagons only occur in a finite range of the control parameter and their interval of existence shrinks to zero with increasing values of the modulation amplitude. Furthermore depending on the modulation amplitude the transition between stripes and distorted hexagons is either sub- or supercritical.

SYSS 3.24 Thu 16:00 P1

On hexagonal, square and stripe pattern of the ion-channel density in biomembranes — •Markus Hilt and Walter Zimmermann — Theoretische Physik Ia, Universität Bayreuth

Ion flow through channels in a membrane undergoing density fluctuations may cause lateral gradients of the electrical potential across the membrane which give rise to electrophoresis of charged channels. A model for the coupled dynamics of the channel density and the voltage drop across the membrane (cable equation), including a binding-release reaction with the cell skeleton (P. Fromherz and W. Zimmerman, Phys. Rev. E **51**, R1659 (1995)) is analyzed in one and two spatial dimensions. This coupled dynamics may give rise to spatial periodic modulations of the channel density, where the wavenumber decreases with the kinetic rate of the binding release reaction. In a two-dimensional extended membrane hexagonal modulations of channel density are preferred in a large range of parameters. The stability diagrams of the periodic patterns near threshold and the anharmonic shape of the solutions far beyond threshold are calculated as well as the equations of motion in the limit of a slow binding release kinetics are derived.

SYSS 3.25 Thu 16:00 P1

Dynamics of defect formation in the Swift-Hohenberg equation — •Tobias Galla[1,2] and Esteban Moro[3,2] — [1]The Abdus Salam International Centre for Theoretical Physics Trieste, Italy — [2]Theoretical Physics, University of Oxford, UK — [3]Dept of Mathematics University Carlos III Madrid, Spain

We present numerical and analytical studies of the dynamics of defect formation during a finite-time quench of the two dimensional Swift-Hohenberg (SH) model of Rayleigh-Benard convection. We find that the Kibble-Zurek picture of defect formation can be applied to describe the density of defects produced during the quench. Our study reveals the relevance of two factors: the effect of local variations of the striped patterns within defect-free domains and the presence of both point-like and extended defects. Taking into account these two aspects we are able to identify the characteristic length scale selected during the quench and to relate it to the density of defects. We discuss possible consequences of our study for the analysis of the coarsening process of the SH model.

SYSS 3.26 Thu 16:00 P1

Spatially periodic modulation of an oscillating chemical reaction — •Martin Hammele and Walter Zimmermann — Theoretische Physik, Universität Bayreuth

The effects of spatially periodic forcing on an oscillating chemical reaction as described by the Lengyl-Epstein model are investigated. The forcing, which enters additively into the model, leads to a spatially periodic pattern that is either harmonic or subharmonic with respect to the external spatially periodic forcing. The subharmonic pattern is found in a large parameter range by numerical solutions of the full model as well by the analysis of an amplitude equation derived from the basic model. Both approaches agree up to fairly large modulation amplitudes.

SYSS 4 Structure Formation and Self-Organization in non-equilibrium Systems III

Time: Friday 10:15–12:45 Room: HSZ 04

Invited Talk

SYSS 4.1 Fri 10:15 HSZ 04

Experiments on structure formation in complex continua — •Ingo Rehberg, Christof Krülle, Reinhard Richter, and Wolfgang Schöpf — Universität Bayreuth

We compare experiments with with respect to their pattern forming properties. In particular we investigate the dynamics of gelified liquid crytals (1) under the influence of an electric field, magnetic fluids driven by magnetic fields (2) and granular matter fluidized by vibration(3,4).

1) Planar-fingerprint transition in a thermoreversible liquid crystalline gel Alberto de Lózar, Wolfgang Schöpf, Ingo Rehberg, Oscar Lafuente and Günter Lattermann, Physical Review E 71 , 051707-1 (2005)

2) Fluid pumped by magnetic stress Robert Krauss, Mario Liu, Bert Reimann, Reinhard Richter, and Ingo Rehberg, Applied Physics Letters 86 , 024102-1 (2005)

3) Sublimation in a vibrated granular monolayer: coexistance of gas and solid A. Götzendorfer, J. Kreft, C.A. Kruelle, and I. Rehberg, Physical Review Letters 95 , 135704 (2005).

4) A horizontal Brazil-nut effect and its reverse T. Schnautz, R. Brito, C.A. Kruelle, and I. Rehberg, Physical Review Letters 95 , 028001 (2005).

Invited Talk

SYSS 4.2 Fri 10:45 HSZ 04

Coarsening versus lengthscale persistence in nonequilibrium pattern-forming systems — •Chaouqi Misbah[1] and Paolo Politi[2] — [1]Laboratoire de Spectrométrie Physique, CNRS, Univ. J. Fourier, Grenoble 1, BP87, F-38402 Saint Martin d'Hères, France — [2]Istituto dei Sistemi Complessi, Consiglio Nazionale delle Ricerche, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy

Global evolution of nonequlibrium pattern-formming systems can be broadly classified into two important classes: (i) those which present a

persistent length scale, (ii) those which undergo a perpetual coarsening. A general criterion about coarsening for a class of nonlinear evolution equations describing one dimensional pattern-forming systems will be presented. This criterion allows one to discriminate between the situation where a coarsening process takes place and the one where the wavelength is fixed in the course of time. An intermediate scenario may occur, namely 'interrupted coarsening'. The power of the criterion lies in the fact that the statement about the occurrence of coarsening, or selection of a length scale, can be made by only inspecting the behavior of the branch of steady-state periodic solutions. The criterion states that coarsening occurs if $\lambda'(A) > 0$ while a lengthscale selection prevails if $\lambda'(A) < 0$, where λ is the wavelength of the pattern, and A the amplitude of the profile (prime refers to differentiation). This is established thanks to the analysis of the phase diffusion equation of the pattern. The phase diffusion coefficient (which carries a kinetic information)is connected to $\lambda'(A)$, which refers to a pure steady-state property. The relationship between kinetics and the behavior of the branch of steady-state solutions, is established fully analytically for a class of equations. Another result which emerges from this study is that the exploitation of the phase diffusion equation enables us to determine in a rather straightforward manner the dynamical coarsening exponent. Our calculation is exemplified on several nonlinear equations, showing that the exact exponent is captured. Contrary to many situations where the one dimensional character has proven essential for the derivation of the coarsening exponent, the present idea can be used, in principle, at any dimension. Some speculations about the extension of the present results will be outlined.

Invited Talk

SYSS 4.3 Fri 11:15 HSZ 04

Spatio-temporal chaos and defects in pattern-forming systems — •H. Riecke — Department of Engineering Sciences and Applied Mathematics, Evanston

Many systems undergo bifurcations from a spatially homogeneous state to a state that exhibits spatio-temporal structures. In simple cases the resulting patterns are ordered in space and time. Often, however, they are spatio-temporally chaotic. What is the origin of such states, what mechanisms maintain them, how can they be characterized? For patterns that are stripe-like (lamellar) these questions have been addressed in quite some detail for various systems. In more detail I will present results for spatio-temporal chaos arising from patterns with hexagonal planform. They arise, for instance, in non-Boussinesq fluid convection. I will focus on three states: defect chaos of whirling hexagons, penta-hepta defect chaos in which penta-hepta defects induce the nucleation of dislocations, and whirling chaos driven by the interplay of defects and an oscillatory whirling mode. Our results are based on Ginzburg-Landau, Swift-Hohenberg, and Navier-Stokes equations.

Invited Talk

SYSS 4.4 Fri 11:45 HSZ 04

Self-organization and collective decision making in animal societies — •Jean-Louis Deneubourg — Unit if Social Ecology, Universite Libre de Bruxelles, 1050 Bruxelles, Belgium

This talk gives an overview on the collective decision making process in animal societies. Experiments with ants and other social insects show the formation of various self-organized patterns. As an example, route choice experiments with ants indicate that crowding is avoided by a change of the temporal organization of the ants.

Invited Talk

SYSS 4.5 Fri 12:15 HSZ 04

Time-delayed feedback control of noise-induced patterns — •Eckehard Schöll, Alexander Balanov, Johanne Hizanidis, and Grischa Stegemann — Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin

Effects of time-delayed feedback on spatio-temporal patterns induced by Gaussian white noise are studied. It is shown that such a feedback in the form proposed earlier by Pyragas for the control of deterministic chaos can be used for effective manipulation of the coherence and the timescales of stochastically oscillating patterns. This is illustrated for globally coupled reaction-diffusion systems.