DY 54: Posters - Pattern Formation, Reaction Diffusion, Chimera

Time: Thursday 17:00–19:30 Location: P1A

DY 54.1 Thu 17:00 P1A

Magnetic Hills — •Constantin Geier[1] and Thomas Grillenbeck[1,2] — [1]Ignaz-Günther-Gymnasium Rosenheim — [2]Rosenheim University of Applied Sciences

A small amount of a ferrofluid placed in an inhomogeneous magnetic field forms hill-like structures. We investigate how the properties of these structures depend on relevant parameters.

DY 54.2 Thu 17:00 P1A

Stability of amplitude chimeras in oscillator networks — Liudmila Tumash[1], Anna Zakharova[1], Judith Lehnert[1], Wolfram Just[2], and •Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Queen Mary, University of London, London E1 4NS, UK

We show that amplitude chimeras in ring networks of Stuart-Landau oscillators with symmetry-breaking nonlocal coupling represent saddle-states in the underlying phase space of the network [1]. Chimera states are composed of coexisting spatial domains of coherent and of incoherent oscillations. We calculate the Floquet exponents and the corresponding eigenvectors in dependence upon the coupling strength and range, and discuss the implications for the phase space structure. The existence of at least one positive real part of the Floquet exponents indicates an unstable manifold in phase space, which explains the nature of these states as long-living transients. Additionally, we find a Stuart-Landau network of minimum size $N = 12$ exhibiting amplitude chimeras.

[1] L. Tumash, A. Zakharova, J. Lehnert, W. Just, E. Schöll, arXiv:1611.03348 (2016).

DY 54.3 Thu 17:00 P1A

Chimera states in networks of Van der Pol oscillators with hierarchical connectivities — Jakub Sawicki, Stefan Ulonska, Iryna Omelchenko, Anna Zakharova, and •Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Germany

Chimera states are complex spatio-temporal patterns that consist of coexisting domains of coherent and incoherent dynamics. We analyse chimera states in networks of Van der Pol oscillators with hierarchical (fractal) connectivities [1]. We investigate the stepwise transition from a nonlocal to a hierarchical topology, and adapt various quantifications to establish a link between the existence of chimera states and the compactness of the initial base pattern of a hierarchical topology; we show that a large clustering coefficient promotes the occurrence of chimeras. Depending on the level of hierarchy and base pattern, we obtain chimera states with different numbers of incoherent domains. We investigate the chimera regimes as a function of coupling strength and nonlinearity parameter of individual oscillators.

[1] S. Ulonska, I. Omelchenko, A. Zakharova, and E. Schöll, Chaos 26, 094825 (2016)

DY 54.4 Thu 17:00 P1A

Numerical simulation of polygonal patterns in salt playa — •Marcel Ernst[1], Jana Lasser[1], and Lucas Goehring[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany — [2]School of Science and Technology, Nottingham Trent University, Clifton Lane, Nottingham, NG11 8NS, UK

In salt pans and playa we sometimes observe that salt crystallization due to evaporation forms polygonal salt-ridge patterns on the surface. Ridges of crystalized salt surround a flat center with a characteristic length scale of about one meter. We aim to understand the development of those polygonal structures as there is currently no comprensive theory of their formation, and different approaches to describing them range from wrinkling to cracking of the surface; none of these mechanisms reproduce the characteristic length scale of the pattern. Here we investigate a numerical model that includes the subsurface dynamics of the salt water-filled porous medium below the crust: salinity gradients drive convection cells which, in turn, interact with the development of salt ridges at the surface. The typical length scales of those convection rolls is consistent with the observed patterns. We use semi-spectral Fourier Galerkin methods to simulate the convection-diffusion-dynamics in the system and complex boundary conditions on the surface in a simplified 2d-model. We compare our results with similar experiments in Hele-Shaw cells and measurements of salt polygons in the field.

DY 54.5 Thu 17:00 P1A

Formation of Crack Patterns in drying Mud Layers — •Tobias-Emanuel Regenhardt[1], Pawan Nandakishore[1,2], and Lucas Goehring[1,3] — [1]Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany — [2]National Centre for Biological Sciences, Bellary Road, Bangalore 560065, Karnataka, India — [3]School of Science and Technology, Nottingham Trent University, Clifton Lane, Nottingham, NG11 8NS, UK

Formation of crack patterns in drying or cooling layers is controlled by the cracking layer itself and external factors. The geometric structure of any underlying substrate layer can have substantial influence on the pattern evolving above. Cracking phenomena can range from the drying of mud in riverbeds to the cooling of lava resulting in crack networks kilometers across. However, the mathematics behind the modeling of these cooling or drying systems is the same, and scale-free. Inspired by graben systems found on Mercury, of which some show clear circular symmetry, the question arises whether these particular patterns evolved due to craters buried below. We used drying mud slurry to create cracking patterns on various crater shapes, scaled down to lab size. We chose craters from Mars and idealized bowl-shaped craters and collect information on the resulting crack networks. Using image analysis of photos taken from the patterns we show the connection between the orientation of the cracks, enclosed cracked regions and the length scales of the systems (layer height, crater aspect ratio). This opens opportunities in the future to study buried craters and similar structures from satellite imagery, in otherwise inaccessible locations.

DY 54.6 Thu 17:00 P1A

Resonating Glass — •Lisa Kastenhuber[1], Adrian Ebert[2], and Thomas Grillenbeck[1] — [1]Ignaz-Gynther-Gymnasium Rosenheim, Germany — [2]Universität Bayreuth, Fakultät für Physik, Germany,

Everybody knows the phenomenon which can often be seen in movies: A singer sings at a glass with such a high volume that the glass will break. The precondition is that the singer meets the resonance frequency. Shortly before the glass breaks interesting oscillation patterns occure. We study these patterns and the relevant parameters they depend on.

DY 54.7 Thu 17:00 P1A

Modeling and simulation of vascular endothelial calcium waves induced by blood shear stress — •Hengdi Zhang and Chaouqi Misbah — Liphy, Laboratoire Interdisciplinaire de Physique, 140 Rue de la Physique, 38402 Saint-Martin-d Heres, France

Vascular endothelial cells form an inner monolayer in human blood vessel. As they are directly contacting with blood flow, a lot of blood vessel functions are modulated or initiated by them, such as vasodilation / vasoconstriction in blood pressure control and angiogenesis in wound healing. These functions require endothelial cells to be capable of sensing its micro environment changes and signaling to surrounding tissues. One of the most important micro environments is the blood flow induced shear stress on the endothelial surface. Endothelial cells respond to the shear stress change in multiple time scales. But for the very first tens of seconds during and after the shear stress change, a transient increase in cytosolic free calcium ion concentration will take place. This calcium signal involves and triggers signaling cascades in many endothelial functions. To get a further understating to this signal, we analyzed possible candidates of endothelial mechanical sensors from relevant literatures, and integrated them into a convection-diffusion-reaction model coupled with shear / shear-rate dependent complex boundary conditions. A Lattice-Boltzmann method is employed to solve the system numerically. Responses to different flow condition and roles of mechanical sensor candidates are investigated in this research.

DY 54.8 Thu 17:00 P1A

Lamellae and dipolar ordering in fluid mixtures of hard nematic rods and dipolar spheres — •Alice C. von der Heydt and Sabine H. L. Klapp — Inst. of Theoret. Physics, TU Berlin, Secr. EW 7-1, Hardenbergstr. 36, 10623 Berlin, Germany

Suspensions of dipolar, e.g., magnetic particles in a liquid crystal (LC) [1] continue to stimulate scientific activity due to interesting properties such as dipolar chain formation and spontaneous magnetisation induced by the LC [2]. Microdomains coupled to LC order already appear in mixtures of differently shaped particles with hard-body repulsion only [3]. Our study focuses on the even richer phase behaviour in mixtures of hard, parallelly aligned LC rods and dipolar spheres able to display smectic density *and* dipolar orientation patterns. To systematically extract the prerequisites for ordering, we identify and analyse a free-energy functional of suitable collective order parameters. The long-range, anisotropic dipolar interaction is considered with continuous spatial, angular, and strength variables. A stability analysis sheds light on the coupling of smectic, component-density, and dipolar ordering in the control-parameter space of packing fraction, sphere density, and dipolar strength. For rods and spheres of similar size, lamellar phase separation is seen to be the dominant effect.

[1] F. Brochard, P.-G. de Gennes, J. Phys. - Paris **31**, 691 (1970)
[2] S. D. Peroukidis, K. Lichtner, S. H. L. Klapp, Soft Matter **11**, 5999 (2015)
[3] Z. Dogic, D. Frenkel, S. Fraden, Phys. Rev. E **62**, 3925 (2000)

DY 54.9 Thu 17:00 P1A

Membrane Instability Driven by an AC Electric Field — •Mirko Ruppert[1], Walter Zimmermann[1], and Falko Ziebert[1,2] — [1]Theoretische Physik, Universität Bayreuth, Bayreuth, Germany — [2]Physikalisches Institut, Universität Freiburg, Freiburg, Germany

Unilamellar vesicles are important model systems in biophysics. They are typically created by applying a voltage on a stack of flat membrane bilayers, but this so-called electroformation process is still poorly understood. Models exist for the case of a static (dc) electric field, but experimentally typically ac fields of about 10 Hz have to be used. We therefore study the ac field-induced instability of a flat capacitive membrane with respect to spatial modulations, using an effective zero-thickness model developed previously in the dc case. The instability of the membrane is driven by the charge accumulation in the Debye layers and the voltage drop at the membrane. Increasing the driving frequency or reducing the amount of salt reduces the instability. By a full Floquet analysis of the linear, coupled Poisson-Nernst-Planck-Stokes boundary value problem we found that the instability is with respect to finite wavenumber undulations, in contrast to the static case where the instability is long-wavelength.

DY 54.10 Thu 17:00 P1A

Nonlinear patterns shape the domain on which they from — •Mirko Ruppert[1], Fabian Bermann[1], Lisa Rapp[1], Falko Ziebert[2], and Walter Zimmermann[1] — [1]Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Physikalisches Institut, Universität Freiburg, Freiburg, Germany

In recent experiments with liquid drops on vertically vibrated surfaces [1,2] the formation of Faraday surface waves was investigated. By increasing the vibration amplitude, the magnitude of the surface stripe pattern increases and in addition the initially circular drop deforms into an elliptical or even a wormlike shape. We here present a model for stationary stripe patterns within an arbitrarily shaped domain, wherein pattern formation is restricted to a finite domain [3] of fixed area by coupling the Swift-Hohenberg model to a phase field. We investigate the self-consistent interplay between the pattern formation process and the shape of the domain on which it takes place.

[1] G. Pucci, E. Foret, M. Ben Amar, Y. Couder, Phys. Rev. Lett. 106, 024503 (2011)
[2] A. Hemmerle, G. Froehlicher, V. Bergeron, T. Charitat, J. Farago, EPL 111, 24003 (2015)
[3] L. Rapp, F. Bergmann, W. Zimmermann, EPL 113, 28006 (2016)

DY 54.11 Thu 17:00 P1A

Wavenumber Restriction for Traveling Waves via Parameter Variations (Ramps) — •Samuel Grimm, Fabian Bergmann, Lisa Rapp, and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth, Deutschland

We investigate the problem of wavenumber selection of traveling waves (TWs) by spatial variations of the control parameter and the oscillation frequency within a complex Swift-Hohenberg equation [1] and coupled Ginzburg-Landau equations.

As is well known, for a given parameter set, a whole band of stable wavenumbers is possible for both stationary [2] and TW patterns [3]. Additionally, in realistic systems, parameters are often spatially inhomogeneous. These parameter variations further influence pattern formation. In stationary systems, e.g., parameter ramps may lead to wavenumber selection or even an orientational selection of patterns ([4] and references therein). For nonlinear TWs, smooth parameter ramps may lead to wavenumber restriction and interesting spatio-temporal behavior [5].

Here, we determine the influence of slow, as well as non-adiabatic parameter variations on the width of the stable wavenumber band for TWs and their spatio-temporal behavior. Can spatio-temporal chaotic behavior of TWs be tamed by spatial parameter variations?

[1] B. A. Molomed, Z. Physik B **55**, 241 (1984); [2] L. Kramer and W. Zimmermann, Physica A **16** 221 (1985); [3] B. Janiaud et al. Physica D **55**, 269 (1992); [4] L. Rapp, F. Bergmann, W. Zimmermann, EPL **113**, 28006 (2016); [5] B. A. Malomed, Phys. Rev. E **47**, R2257 (1993).

DY 54.12 Thu 17:00 P1A

Rectangular and branched Wrinkle patterns in inhomogeneous film substrate systems — •A. Zippelius, R. Aichele, M. Hilt, B. Kaoui, F. Ziebert, and W. Zimmermann — Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth, Germany

We study wrinkles on thin hard skins supported by elastic substrates under uniaxial (anisotropic case) and biaxial compression. We use generic models and the full elastic equations for the skin substrate system [1,2]. For homogeneous skin layers the preferred wave-vector of wrinkles points along the major compression direction (anisotropy). As recent experimental studies show [2], a spatial variation of the substrate elasticity (bending elasticity of the skin [3]) perpendicular to the anisotropy triggers branched wrinkle patterns. One observes coexistence of many branched wrinkle patterns of different wavenumbers and branching points densities, which are stable at identical parameters. This corresponds to a generalization of the concept (Eckhaus) stability bands to inhomogeneous systems.

For a spatial variation of the skin elasticity along the preferred (load) direction and with the modulation wavenumber of the order of that of the wrinkles, we predict and characterize rectangular wrinkle patterns.

[1] B. Kaoui, A. Guckenberger, A. P. Krekhov, F. Ziebert and W. Zimmermann, New J. Phys. **17**, 103015 (2015); [2] B. A. Glatz, M. Tebbe, B. Kaoui, R. Aichele, C. Kuttner, A. E- Schedl, H. W. Schmidt and W. Zimmermann, A. Fery, Soft Matter **11**, 3332 (2015); [3] J. Wang, B. Li, Y.-P. Cao, X.-Q. Feng, H. Gao, Appl. Phys. Lett. **106**, 021903 (2016)

DY 54.13 Thu 17:00 P1A

Stability of periodic, stationary patterns in conserved systems — •F. Dietl, F. Bergmann, L. Rapp, and W. Zimmermann — Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth, Germany

Pattern formation in systems with conserved fields is considered by studying an extended Cahn-Hilliard model. This model shows either a bifurcation to a stationary periodic pattern or a large scale phase separation. We investigate the stability of nonlinear, stationary periodic patterns, as well as the evolution of the nonlinear patterns, including the transition to a coarsening regime. We also describe possible applications and extensions of the model to vegetation patterns.