BP 60: Pattern Formation (Joint Session with DY)

Time: Thursday 9:30–13:00 Location: H46

Invited Talk BP 60.1 Thu 9:30 H46

Patterns formation through elastic instabilities, from thin sheets to twisted ribbons — •Pascal Damman — Université de Mons, Mons, Belgium

Hydrodynamics instabilities, such as Bénard-Marangoni convection, Rayleigh-Plateau, Rayleigh-Taylor and many others, are well known to produce beautiful patterns. Capillary, viscous and/or inertial forces conspire to generate very regular morphologies. In this seminar, we will see that elasticity can also produce complex structures, either regular or fully random, provided that slender objects are used. These objects are usually classified as rods, shells or sheets.

In the "classical picture", thin sheets constrained by external forces minimize the elastic energy through focalization of deformation in singularities. We will see that, due to geometric constraints, these origami structures cannot always be obtained. In the second part, the formation of very regular wrinkles in sheets "glued" on a soft foundation will be discussed. At the threshold, these wrinkles reflect the competition between various forces. For large deformations, however, the morphology is surprisingly determined by the nature of the foundation. Fold localization or period-doubling bifurcations are indeed observed for liquid or solid substrate, respectively. Finally, the effect of specific geometrical constraints produced by twisting thin ribbon of elastic materials will be discussed.

Finally, these various studies also highlight the effort of this growing interdisciplinary researcher community to the emergence of a global picture of elastic instability.

BP 60.2 Thu 10:00 H46

Shear driven instabilities in hard–core anisotropic colloids: Pressure tensor dynamics — •Henning Reinken, Rodrigo Lugo-Frias, and Sabine H. L. Klapp — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Systems of hard anisotropic particles display interesting flow induced behavior that modifies their internal structure and rheological properties [1, 2]. In soft matter theory, using the well known Doi–Hess approach, these systems have been studied in the bulk [3] and close to the boundaries [4].
Within this framework, we study how the pressure tensor is influenced by the average orientation of the particles coupled to the velocity field. To do so, we start from an isotropic or nematic equilibrium configuration and apply simple shear flow (Couette geometry) observing the emergence of instabilities (shear banding) in both scenarios. A novel finding is the appearance of coexisting stationary and oscillatory dynamics within the bands. We also discuss the resulting stress-strain relations.

[1] S. M. Fielding, Soft Matter, **3**, 1262-1279 (2007).
[2] J. K. G. Dhont, M. P. Lettinga, *et al.*, Faraday Discuss, **123**, 157-172 (2003).
[3] D. Strehober, H. Engel and S. H. L. Klapp, Phys. Rev. E **88**, 012505 (2013).
[4] S. Heidenreich, P. Ilg, and S. Hess, Phys. Rev. E **75**, 066302 (2007).

BP 60.3 Thu 10:15 H46

Towards a more thorough understanding of dislocation contributions in shape-memory alloys — •Heike Emmerich[1] and Julia Kundin[2] — [1]Universität Bayreuth, Lehrstuhl Material- und Prozesssimulation, Universitätsstraße 30, D-95447 Bayreuth — [2]Universität Bayreuth, Lehrstuhl Material- und Prozesssimulation, Universitätsstraße 30, D-95447 Bayreuth

The scientific interest in solid state cooling technologies has been renewed and increased since the discovery of of new materials with giant ferrocaloric effects - and with it the interest in understanding the hysteresis effects associated with the rise of crystal defect evolution as a result of plastic deformations at diverse time scales more thoroughly. In this contribution we show how phase-field modeling including elastic and plastic contributions tight to incoherent martensitic phase transitions can contribute to shade light into this scenario. Additionally we elucidate from a fundamental point of view how the associated enthalpic contributions can be reconciled and validated with atomistic concepts.

BP 60.4 Thu 10:30 H46

Pattern orientation in finite domains without boundaries — •Lisa Rapp, Fabian Bergmann, and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth, Germany

We investigate the orientation of nonlinear stripe patterns in finite domains. Motivated by recent experiments, we introduce a control parameter drop from supercritical inside a domain to subcritical outside without boundary conditions at the domain border. As a result, stripes align perpendicular to shallow control parameter drops. For steeper drops, non-adiabatic effects lead to a surprising orientational transition to parallel stripes with respect to the borders. We demonstrate this effect in terms of the Brusselator model and generic amplitude equations. Preprint available at arXiv:1512.05576 [cond-mat.soft]

BP 60.5 Thu 10:45 H46

Reflection and orientation of nonlinear traveling waves in finite domains without boundaries — •Fabian Bergmann, Lisa Rapp, and Walter Zimmermann — Theoretische Physik, Universitaet Bayreuth, Bayreuth, Germany

We investigate the reflection and orientation of nonlinear traveling waves in finite domains. In a finite domain (part of large system) the control parameter is assumed to be supercritical inside the domain and to drop to subcritical values outside. In 2d systems we find that a control parameter drop orients the propagation of traveling waves parallel to the domain boundaries. In quasi 1d systems steep control parameter variations at the ends of a finite domain cause reflections of traveling waves. Steep drops may also lead to complex spatio-temporal scenarios inside the finite domain. This study is motivated by recent experiments [1], where traveling waves in finite stripes have been investigated. Our analysis is compared with a recent work on stationary stripe patterns in finite domains without boundary conditions for the dynamical fields [2].

[1] J. Schweizer, M. Loose, M. Bonny, K. Kruse, I. Moench, P. Schwille, Proc. Natl. Acad. Sci. (USA)109, 15283 (2012)
[2] L. Rapp, F. Bergmann, W. Zimmermann, arXiv:1512.05576 (2015)

15 min. break

BP 60.6 Thu 11:15 H46

Self-assembly in colloidal systems with tunable particle interactions — •Hauke Carstensen, Vassilios Kapaklis, and Max Wolff — Dept of Physics & Astronomy, Box 516, SE-751 20 Uppsala, Sweden

We present a system that allows tunable magnetic self-assembly of microbeads. Two types of beads, magnetic and non-magnetic ones, are dispersed in a ferrofluid (FF), which alters their effective magnetic behaviour. By changing the FF concentration, the interactions between the beads can be tuned. The particles are confined in two dimensions. Depending on the interaction and the particle composition, lattices like square or hexagonal are assembled. Additionally, in less dense conditions metastable structures like branching chains are observed. The samples are analysed by transmission optical microscopy and images are taken in a scanning mode. Sets of images can be stitched together to create large scale maps of each sample. The particle positions are extracted by image analysis. Phases are detected via characteristic angles and lattice constants. A phase diagram is created by combining the observed phases with the particle interactions and the sample compositions. This can be applied to the fundamental understanding of colloidal crystal formation and chain formation in magnetorheological fluids.

BP 60.7 Thu 11:30 H46

Subcritical chaos and localized convection in the asymptotic suction boundary layer over a heated plate — •Stefan Zammert[1] and Bruno Eckhardt[1,2] — [1]Fachbereich Physik, Philipps-Universität Marburg, D-35032 Marburg, Germany — [2]J.M. Burgerscentrum, Delft University of Technology, 2628 CD Delft, The Netherlands

The asymptotic suction boundary layer over a heated plate, a parallel and open flow, can be considered as a model for the properties of thermal boundary layers. A stability analysis of the base state

shows that the flow undergoes a subcritical instability with increasing Rayleigh number. This instability creates spatially periodic convection patterns. We will show how bifurcations of these secondary solutions create a chaotic attractor in the subcritical regime which is turned into a chaotic saddle by a crisis bifurcation. Long-wavelength instabilities of the secondary solutions create various stationary convection solutions which are localized in one or two directions parallel to the plate. These localized structures also exist in subcritical regime and can potentially be used to study plume dynamics in thermal boundary layers.

BP 60.8 Thu 11:45 H46

Spontaneous autocatalysis in a primordial broth — •Sabrina Scherer[1], Eva Wollrab[2], Varun Giri[1], and Albrecht Ott[1] — [1]Biologische Experimentalphysik, Universität des Saarlandes — [2]Laboratory of Microbial Morphogenesis and Growth, Institut Pasteur

Driven non-linearities lead to pattern formation. Here we study the dynamics of a complex chemical system, driven by electric discharge that forms from a gas mixture of methane and ammonia in the presence of water. Using real-time mass spectrometry, we observe the generation of a primordial broth composed of thousands of different molecules in a mass range from 50 to 1000 Dalton. The temporal development of the primordial broth reveals the spontaneous emergence and disappearance of oligomeric surfactants. Strong non-linearities are required for these aperiodic chemical oscillations. The phenomenon is robust against different gas compositions and concentrations, temperatures and many details of the experimental set-up. We analyze the chemical composition of the solution by different methods like (high-resolution) mass spectrometry, NMR and gas-chromatography to find high-reactive molecules and possible catalysts. We find that oxidation and doping with small amounts of an active broth can trigger the production of the oligomers. We suggest that surface active molecules lead to phase transfer catalysis in the oil/water mixture and self-organize to a spontaneously emerging autocatalytic network.

BP 60.9 Thu 12:00 H46

A Protein Flux-based Mechanism for Midcell Sensing in Bacteria — •Silke Bergeler[1], Dominik Schumacher[2], Lotte Søgaard-Andersen[2], and Erwin Frey[1] — [1]ASC for Theoretical Physics, Ludwig-Maximilians-Universität, München, Germany — [2]Max Planck Institute for Terrestrial Microbiology, Marburg, Germany

Precise positioning of the cell division site is crucial for the correct separation of the genetic material into the two daughter cells. In myxobacteria a cluster of Pom proteins (PomX, PomY, PomZ) is formed on the chromosome that performs a biased random walk to midcell and positively regulates cell division. To investigate how the Pom cluster, consisting of PomX and PomY, moves to midcell, we introduce a mathematical model in which PomZ dimers can attach to, diffuse on the nucleoid and can hydrolyze ATP and subsequently detach from the nucleoid primarily at the cluster. It is known that this type of particle dynamics leads to different fluxes of PomZ into the cluster from both sides along the long cell axis, if the cluster is at an off-center position, but it is not known how the force to move the cluster is generated. We model the PomZ dimers as springs, based on the observation that the bacterial chromosome and several proteins have elastic properties. As springs the PomZ dimers can exert a force on the PomXY cluster. Our model explains mid-plane localization of the Pom cluster. It predicts a decrease in the efficiency to find midcell for a large number of PomZ dimers in the cell and small ATP-hydrolysis rates of the ATPase PomZ, which is in agreement with our experimental findings. In summary, our study provides new mechanistic insights into intracellular positioning.

BP 60.10 Thu 12:15 H46

Cyclosis-mediated transfer of reactive oxygen species and its relation to the formation of pH bands in Chara alga cells — •Alexey Eremin[1], Ralf Stannarius[1], Anna Komarova[2], and Alexander Bulychev[2] — [1]Institute of Experimental Physics, Otto von Guericke University Magdeburg — [2]Faculty of Biology, Lomonosov Moscow State University, 119992 Moscow, Russia

In internodal cells of characean algae, cyclosis participates in formation of light-dependent patterns of surface pH and photosynthetic activity. Hydrogen peroxide, being a signalling molecule and a stress factor, is known to accumulate under excessive irradiance. In our study, we explore the spatio-temporal dynamics of pH-band formation on the surfaces of internodal Chara corallina cells and study the kinetics of H2O2 production in chloroplasts and its release into the cytoplasm under local illumination. We demonstrate that in cells exhibiting active streaming, H2O2 first accumulates in the illuminated region and then enters into the streaming cytoplasm. The results suggest that H2O2 released from chloroplasts is transported along the cell with the cytoplasmic flow. It is proposed that the shift of cytoplasmic redox poise and light-induced elevation of cytoplasmic pH facilitate the opening of H+/OH-permeable channels in the plasma membrane.

BP 60.11 Thu 12:30 H46

Improvement of unpinning and termination of spiral waves by reducing excitability — •Jiraporn Luengviriya[1], Malee Sutthiopad[2], Metinee Phantu[2], Porramain Porjai[2], Jarin Kanchanawarin[2], Stefan C. Müller[3], and Chaiya Luengviriya[2] — [1]Department of Industrial Physics and Medical Instrumentation, King Mongkut's University of Technology North Bangkok, Thailand — [2]Department of Physics, Kasetsart University, 50 Phaholyothin Road, Jatujak, Bangkok 10900, Thailand — [3]Institute of Experimental Physics, Otto-von-Guericke University Magdeburg, Universitätsplatz 2, D-39106 Magdeburg, Germany

Spiral waves are common found in excitable systems. Such waves may drift and eventually annihilate at the boundary. However, they can be stabilized when pinned to obstacles. Spiral waves of electrical excitations in cardiac systems connect to some arrhythmias so that they should be eliminated. We present an investigation of the release of pinned spiral waves from unexcitable obstacles and the termination of free spiral waves at the boundary in a reaction-diffusion system. An advective field is applied as the external forcing. For a given obstacle size, the critical value of advection to release as well as that to terminate the spiral waves decrease when the excitability of the system is reduced. Therefore, this study shows that decreasing the excitability can facilitate elimination of spiral waves, either in the presence of obstacles or not.

BP 60.12 Thu 12:45 H46

Coexistence of stable branched patterns in anisotropic inhomogeneous systems — Badr Kaoui[1,2], Achim Guckenberger[1], Alexei Krekhov[1,3], Falko Ziebert[1,4], and •Walter Zimmermann[1] — [1]Theoretische Physik, Universitaet Bayreuth, Bayreuth, Germany — [2]Biomechanics and Bioengineering, Universite de Technlogie de Compiegne, Compiegne, France — [3]Max-Planck-Institute for Dynamics and Self-Organization, Goettingen, Germany — [4]Physikalisches Institut, Albert-Ludwigs-Universitaet Freiburg, Freiburg, Germany

A new class of pattern forming systems is identified and investigated: anisotropic systems that are spatially inhomogeneous along the direction perpendicular to the preferred one. By studying the generic amplitude equation and a model equation, we show that branched stripe patterns emerge, which for a given parameter set are stable within a band of different wavenumbers and different numbers of branching points (defects). Moreover, the branched patterns and unbranched ones (defect-free stripes) coexist over a finite parameter range. We propose two systems where this generic scenario can be found experimentally, surface wrinkling on elastic substrates and electroconvection in nematic liquid crystals, and relate them to the findings from the amplitude equation.

B. Kaoui, A. Guckenberger, A. Krekhov, F. Ziebert, W. Zimmermann, New J. Phys. 17, 103015 (2015); B. A. Glatz, M. Tebbe, B. Kaoui, R. Aichele, C. Kuttner, A. E. Schedl, H.-W. Schmidt, W. Zimmermann, A. Fery, Soft Matter 11, 3332 (2015)