DY 31: Poster - Pattern Formation

Time: Tuesday 18:15–21:00 Location: Poster C

DY 31.1 Tue 18:15 Poster C

Delay-Induced Dynamics of Localized Structures in Systems with Spatial Inhomogeneities — •Felix Tabbert and Svetlana Gurevich — Institut für Theoretische Physik, Münster

We are interested in the stability properties of localized structures subjected to time-delayed feedback in systems with spatial inhomogeneities. Therefore, a Swift-Hohenberg model that describes the behaviour of transversal patterns in a passive cavity in two spatial dimensions is combined with an additional time-delayed feedback term and an inhomogeneous gaussian injection beam.

We show that varying the delay strength, the delay time and the shape of the injection beam leads to various dynamical solutions including drifting solutions, pinned oscillatory structures and the formation of spirals. The onset of these different instabilities can be predicted analytically in terms of a linear stability analysis of the delayed systems.

A special focus lies on the competing effects of the symmetry breaking inhomogeneity, which has a pinning effect on the localized structure, and the drift-inducing modes, which can be destabilized by time delayed feedback. The interplay of these competing effects leads to an oscillatory motion of the structure which is studied both numerically and analytically.

DY 31.2 Tue 18:15 Poster C

Patterns in a Flat Rotating Box — •Adrian Ebert[1], Anna Treffurth[1], and Thomas Grillenbeck[1,2] — [1]Ignaz-Günther Gymnasium Rosenheim, Germany — [2]Rosenheim University of Applied Sciences, Germany

If two granulates of different size and texture are filled into a flat container rotating along its horizontal axis, patterns form inside. At lower fill levels, vertical stripes develop; at higher ones, convection occurs reminiscent of rolls in the granular structure. This is astonishing, because, depending on the fill level, nearly no movement is possible and the rolls' rotating sense cannot be caused by the cell rotation. It has to be pointed out that the box must rotate over a long period, ca.10 hours at approximately 20 rotations per minute, in order to get the best results. We examine the various mechanisms which lead to the development of so-called "convection rolls", enabling us to clarify ample connections on the one hand and, on the other, generating completely new observations partially complying with the results of the research at Magdeburg University, but sometimes also raising new questions.

DY 31.3 Tue 18:15 Poster C

Sensitive Flames — •Adrian Ebert[1] and Thomas Grillenbeck[1,2] — [1]Ignaz-Günther-Gymnasium Rosenheim, Germany — [2]Rosenheim University of Applied Sciences, Germany

A combustible gas streams out of a fine nozzle and is lit above a copper mesh at a distance of ca. 5cm. The copper conducts away the heat, thus the flame only burns above the mesh and leaves a space of air underneath it. When an acoustic signal meets the resonance of the flame, delivering a certain amount of energy, the flame reacts very sensitively and changes its shape and size. A fishtail nozzle creates a membrane of fire which, in theory, allows an even easier influence. We examine this phenomenon, in order to spot the influence of various parameters.

DY 31.4 Tue 18:15 Poster C

Crystal growth in a channel: effects of the crystalline anisotropy — •Klaus Kassner[1], Jean-Marc Debierre[2], and Rahma Guérin[2] — [1]Otto-von-Guericke Universität Magdeburg, PF 4120, 39016 Magdeburg — [2]Laboratoire Matériaux et Microélectronique de Provence, Aix-Marseille Université, Case 142, F-13397 Marseille Cedex 20, France

Phase-field simulations are performed to explore the thermal solidification of a pure melt in three-dimensional capillaries. Following our previous work for isotropic or slightly anisotropic materials, we now focus on the more general case of anisotropic materials. Different channel cross-sections are compared (square, hexagonal, circular) to reveal the influence of the confining geometry and the effects of a competition between the crystal and the channel symmetries. In particular, the compass effect toward growth directions favored by surface tension is considered. At given undercooling and anisotropy, the simulations generally show the coexistence of several growth modes. The relative stability of these growth modes is tested by submitting them to a strong spatiotemporal noise for a short time. Similarities and differences with experimental growth modes in confined geometry are discussed qualitatively.

DY 31.5 Tue 18:15 Poster C

Measuring the stable range of localised patches of ferrofluidic spikes — •Robin Maretzki, Ingo Rehberg, and Reinhard Richter — Experimentalphysik 5, Universität Bayreuth

Spatial localisation has been predicted for many physical systems, however a comparison of experiment and theory is sparse - see [1] for a review. A convenient experiment is a layer of ferrofluid subjected to a homogeneous magnetic induction B. By applying local magnetic pulses localised radially symmetric spikes [2] have been generated in the bistable regime of the Rosensweig instability. Moreover, utilizing a pulse sequence in B, different localised hexagon patches have been uncovered in experiment [3]. Similar patches have been found as well by applying numerical continuation techniques to the Young-Laplace- and coupled Maxwell equations [3]. They undergo a 'homoclinic snaking' scenario, where each alternating turn of a 'snake' in control parameter phase space is correlated with a discontinuous jump of the topography of the localized pattern. In our contribution we investigate for the first time the range of stability of a patch under continuous variation of B, and the effects of magnetophoresis and magnetoviscosity.

[1] E. Knobloch, *Annu. Rev. Condens. Matter Phys.* **6**, 325 (2015).

[2] R. Richter, I. Barashenkov, *Phys. Rev. Lett.* **94**, 184503 (2005).

[3] D. B. Lloyd, C. Gollwitzer, I. Rehberg, R. Richter, *J. Fluid. Mech.* **783**, 283 (2015).

DY 31.6 Tue 18:15 Poster C

Modelling growth-induced wrinkling of elastic biofilms — •Horst-Holger Boltz and Stefan Klumpp — Faculty of Physics, Institute for Nonlinear Dynamics, Georg-August-Universität Göttingen, 37077 Göttingen, Germany

Microbial biofilms have been an important subject of study in the recent years due to their biological, medical and technolog- ical relevance. Biofilms are large multicellular structures of microorganisms adherent to a substrate. The formation of these structures is usually accompanied by the production of an extracellular matrix formed by so-called extra-cellular polymeric substances (EPS). Thus, an elastic film is created that is growing due to the ongoing cell growth and division as well as the continued production of EPS. This growth leads to residual and dynamic stresses that are relieved by a non-planar pattern-formation (wrinkling). We study the mechanics of this morphoelastic problem.

DY 31.7 Tue 18:15 Poster C

Lattice model of 'sticky' hard rods: Bulk equilibrium and layer growth at a substrate — •Miriam Klopotek[1], Martin Oettel[1], Hendrik Hansen-Goos[2], Yuding Ai[3], Eelco Empting[1], and Frank Schreiber[1] — [1]Institute for Applied Physics, University of Tübingen — [2]Institute for Theoretical Physics, University of Tübingen — [3]Hanover College, IN, USA

We model 3D hard rods in the vicinity of a substrate in a lattice model that includes 'sticky' interactions between the rods and/or with the substrate. This study continues a previous lattice-model study of purely hard-core rods forming a monolayer. Rods in bulk are investigated in equilibrium via grand canonical Monte Carlo (GCMC) methods and rods on a substrate out-of-equilibrium via kinetic Monte Carlo (KMC). Specifically, successive umbrella sampling was employed for bulk-GCMC [1].

We seek to understand the origin of structures that form during growth, i.e. if they stem from equilibrium phases or are the products of kinetic effects. Thin film growth is a topic of fundamental experimental research, in particular for organic molecules with semiconducting properties. Organic molecules are typically highly anisotropic, showing intricate ordering not seen in the case of isotropic molecular/atomistic films [2]. Our models explore the effect of particle anisotropy plus interactions with each other and the substrate.

[1] R.L.C. Vink, S. Wolfsheimer, and T. Schilling, *J. Chem. Phys.*

123(7):074901, 2005.
[2] S. Kowarik et al., *Phys. Rev. Lett.* **96**:125504, 2006.

DY 31.8 Tue 18:15 Poster C

Thin film and kinetic Monte Carlo modeling of Rayleigh-Plateau instabilities of ridges on substrates — Walter Tewes[1], •Oleg Buller[2], Svetlana Gurevich[1], Andreas Heuer[2], and Uwe Thiele[1] — [1]Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, 48149 Münster — [2]Institut für Physikalische Chemie, Westfälische Wilhelms-Universität Münster, 48149 Münster

The Rayleigh-Plateau-like instability of ridges formed by molecules on prepatterned substrates is studied by means of Kinetic Monte Carlo (KMC) simulations and a thin film continuum model. We show systematically the qualitative agreement of the occurring instability in both models. In particular, we demonstrate that in the KMC model the transversal instability of ridges occurs on well defined scales which are significantly larger than the intrinsic scales of thermodynamical fluctuations. In the thin film model, the transversal instabilty for a single ridge and two weakly interacting ridges is investigated through a transversal linear stability analysis. We show the dispersion relations for transversal modulations and investigate their dependency on the system parameters. In regimes accessible to direct simulations, similar results are obtained for the KMC model. Finally a mapping of the two model approaches in terms of energetics and statics is discussed for the case of homogeneous substrates.

DY 31.9 Tue 18:15 Poster C

Network properties of mitochondria in mammalian cells — •Lorenz Stadler, Sven Bauernfeind, and Matthias Weiss — Experimental Physics I, University of Bayreuth

Mitochondria are the power plants of eukaryotic cells. Besides being the production site for ATP, they are involved in many other vital cellular functions, e.g. apoptosis and Ca2+ homoiostasis. In contrast to textbook illustrations, mitochondria typically form extensive networks throughout mammalian cells rather than being individual granule-like organelles. Mitochondrial networks are subject to constant remodeling, i.e. mitochondrial tubes undergo continuous fission and fusion cycles. To gain insights into the network dynamics, we have analyzed mitochondrial phenotypes in untreated and drug-treated HeLa cells by confocal live cell imaging. Using a custom-made analysis tool, we have determined topological, geometrical, and polymeric parameters of the mitochondrial network. As a result, we observed that the overwhelming majority of nontrivial network nodes are three-way junctions with an exponential distribution of connecting link lengths. Moreover, our data suggest an immediate reaction of the mitochondrial network phenotype to a drug-induced breakdown of the cytoskeleton, whereas stabilization of microtubules had little effect.

DY 31.10 Tue 18:15 Poster C

Particle-based computer simulations of the Min-system — •Nikolas D. Schnellbächer[1,2], Artemij Amiranashvili[1,2], and Ulrich S. Schwarz[1,2] — [1]BioQuant, Heidelberg, Germany — [2]Institute for Theoretical Physics, Heidelberg University, Heidelberg, Germany

E. Coli and similar bacteria use a system of so-called Min-proteins to find the middle for cell division. The Min-system can also be reconstituted outside the cellular context and then leads to a variety of dynamic oscillatory patterns whose details depend both on global compartment geometry and local binding kinetics. We use three-dimensional and stochastic particle-based computer simulations to predict pattern formation as a function of geometry. We investigate the stability of different oscillation modes on the same pattern and the stochastic switching between them. We find that the number of membrane bound molecules is independent of the volume to area ratio and establish requirements for a sharp MinE-ring formation, depending on different MinE-binding modes.

DY 31.11 Tue 18:15 Poster C

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 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 capacitive membrane, 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. Increasing the driving frequency reduces this effect. A full Floquet analysis of the coupled Poisson-Nernst-Planck-Stokes boundary value problem is under way.

DY 31.12 Tue 18:15 Poster C

Wavenumber restriction in narrow anisotropic pattern forming systems — •Konstantin Speckner, Fabian Bergmann, Lisa Rapp, and Walter Zimmermann — Theoretische Physik, Universität Bayreuth, Bayreuth, Germany

We investigate stripe patterns in anisotropic pattern forming systems, wherein stripes orient perpendicular (y-direction) to the preferred x-direction. In such systems supercritically bifurcating stripes are stable within a finite range of wavenumbers, the so-called Eckhaus stability band. We study for this class, how spatial variations of the control parameter along the y-direction restrict the band of stable wave numbers? We use simulations of a 2d anisotropic Swift-Hohenberg model where the control parameter is supercritical in a narrow subdomain along the y-axis and then drops down to subcritical values outside that y-domain. The wavenumber range of stable periodic patterns is restricted when the control parameter drops down to subcritical values outside a finite y-domain. We also show that this wavenumber restriction depends on the steepness of such control parameter drops. As a result, the number of defects in stripe patterns evolving from random initial conditions is reduced. Furthermore, we discuss possible applications to wrinkle forming systems.

DY 31.13 Tue 18:15 Poster C

Branched-wrinkles in inhomogeneous film-on-substrate systems — •Roland Aichele[1], Badr Kaoui[1,2], Falko Ziebert[1,3], and Walter Zimmermann[1] — [1]Theoretische Physik, Universitaet Bayreuth, Bayreuth, Germany — [2]Biomechanics and Bioengineering, Universite de Technlogie de Compiegne, Compiegne, France — [3]Physikalisches Institut, Albert-Ludwigs-Universitaet Freiburg, Freiburg, Germany

We model wrinkle formation in thin-solid films supported by soft substrates and subjected to axial compression. Spatial variations of the elasticity of the substrate or of the thin film lead effectively to a spatial variation of the range of accessible wavle-lengths of wrinkle's, and beyond a critical amplitude of the wave-length modulation stable branched wrinkles may emerge. The branching points of the wirnkles are located along step like parameter changes. For a given parameter set, one finds a whole familiy of stable branched periodic pattern and it depends on the initial conditions which of the stable pattern is reached. If parameters change smoothly, the branching points connecting the wrinkles of different wavelength show complex orderings. Smooth parameter variations reduce the stability domains of branched pattern and may lead to complex ordering of the branching points.

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)