DY 44: Pattern Formation

Time: Thursday 9:30–12:15 Location: BH-N 333

DY 44.1 Thu 9:30 BH-N 333

Feedback control and semi-laning in confned colloidal suspensions — •Tarlan A. Vezirov, Sascha Gerloff, and Sabine H. L. Klapp — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany

Colloidal particles under the combined influence of an external driving force and restricted geometry exhibit a wealth of non-linear phenomena, which are relevant in diverse fields such as directed particle transport, sorting mechanisms and friction phenomena at the nanoscale. We perform Brownian Dynamic simulations of strongly confined systems of charged colloidal particles interacting via a combined soft-sphere and Yukawa potential. Under an external shear flow such systems display a sequence of states characterised by pinning, shear-induced melting and reentrant ordering into a moving hexagonal state [1]. Here we focus on the following situations: First, we consider a crystalline bilayer. By adding a feedback equation of motion we are able to stabilise specific properties such as the degree of hexagonal ordering or the shear stress. This opens the route for a deliberate control of friction properties of the system [2]. Second, we consider an open-loop controlled trilayer system. Besides the three states already observed in the bilayer system [1] we observe a novel state, which is characterized by the separation of the middle layer into two sublayers with opposite velocities. This is enabled by the formation of microlanes.

[1] T. A. Vezirov and S. H. L. Klapp, Phys. Rev. E 88, 5 (2013). [2] T. A. Vezirov, S. Gerloff and S. H. L. Klapp, Soft Matter DOI: 10.1039/c4sm01414f (2014).

DY 44.2 Thu 9:45 BH-N 333

Patterns driven by combined ac and dc electric fields in nematic liquid crystals — •Alexei Krekhov[1], Werner Pesch[2], Nandor Eber[3], and Agnes Buka[3] — [1]Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen, Germany — [2]Institute of Physics, University of Bayreuth, 95440 Bayreuth, Germany — [3]Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, H-1525 Budapest, Hungary

Electroconvection and flexoelectric patterns in a nematic liquid crystal layer driven by two superimposed ac and dc voltages, where each of them would separately trigger patterns of different spato-temporal symmetry, are investigated. An extended model of the electrohydrodynamic instabilities was used to characterize the onset of pattern formation in the two-dimensional parameter space of the magnitudes of the ac and dc voltages. It is demonstrated that depending on the type of patterns and on the ac frequency, the combined action of ac and dc fields may either enhance or suppress the formation of spatially periodic patterns. The theoretical predictions are compared with representative experiments.

DY 44.3 Thu 10:00 BH-N 333

Turning Spirals into Fingers: The Impact of Advection on Pattern-Formation in Excitable Media — •Munir Salman, Philipp Bauer, and Katharina Krischer — Physik Department, Nonequilibrium Chemical Physics, TU München, James-Franck-Str. 1, 85748 Garching, Germany

Inspired by experimentally observed solitary waves with non-curling open ends in an electrochemical flow cell, we present simulations in a two dimensional excitable reaction-diffusion-advection system. Depending on the advection strength, the tip of spiral waves can be pushed toward the flow outlet, leaving a uniform system, or driven against the advective flow, resulting in a finger-shaped wave fragment. Thus, the peculiar experimental traveling 'fingers' can be explained by the presence of advective flow in the experimental system.

DY 44.4 Thu 10:15 BH-N 333

Localized states in the conserved Swift-Hohenberg equation (aka the Phase Field Crystal quation) — •Uwe Thiele[1], Andrew J. Archer[2], Mark J. Robbins[2], Hector Gomez[3], and Edgar Knobloch[4] — [1]Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Germany — [2]Department of Mathematical Sciences, Loughborough University, Loughborough, UK — [3]University of A Coruna, 15192 A Coruna, Spain — [4]Department of Physics, University of California, Berkeley, CA, USA

We consider the structure of localised states for the phase field crystal (PFC) model [aka conserved Swift-Hohenberg (cSH) equation with cubic nonlinearity] that may be obtained as a local approximation of a dynamical density functional theory (DDFT) for colloidal crystallisation [1].

We determine the location of steady spatially localized structures in the temperature vs. mean order parameter plane combining numerical continuation in 1d and direct numerical simulation in 2d and 3d. The results are related to the phenomenon of slanted snaking but take the form of standard homoclinic snaking when the mean order parameter is plotted as a function of the chemical potential [2].

[1] H. Emmerich et al., *Adv. Phys.* **61**, 665 (2012). [2] U. Thiele, A. J. Archer, M. J. Robbins, H. Gomez, and E. Knobloch, *Phys. Rev. E.* **87**, 042915 (2013).

DY 44.5 Thu 10:30 BH-N 333

Unveiling the Bifurcation Diagram of Pattern Formation in Surfactant Monolayer Transfer — •Michael Köpf[1] and Uwe Thiele[2] — [1]Departement de Physique, Ecole Normale Superieure Paris, France — [2]Institut für Theoretische Physik, WWU Münster, Germany

Spontaneous pattern formation in deposition processes at receding contact lines has become a versatile tool to coat substrates with well controlled micro- and nanostructures. As a paradigmatic example, the coating of substrates with periodically structured monolayers has in recent years been investigated by theoreticians [1,2] and experimentalists [3,4] alike. Here, we present recent progress [5], allowing for the first time to understand the intricate bifurcation diagram of the system that exhibits a snaking branch of stationary solutions. Each nose of the snake is connected to a branch of time periodic solutions. Using numerical continuation, we detect various local and global bifurcations and investigate how the solution structure depends on the system size. These results are of wide interest for the theoretical description of pattern formation in systems with nontrivial boundary conditions.

[1] Köpf, Gurevich, Friedrich, Thiele, *New J. Phys.* **14** (2012) 02316
[2] Köpf, Gurevich, Friedrich, Chi, *Langmuir* **26** (2010) 10444-10447
[3] Li, Köpf, Gurevich, Friedrich, Chi, *Small* **8** (2012) 488-503
[4] Köpf, Harder, Reiche, Santer, *Langmuir* **27** (2011) 12354-12360
[5] Köpf, Thiele, *Nonlinearity* **27** (2014) 2711-2734

DY 44.6 Thu 10:45 BH-N 333

Faraday Waves as dynamical system under time asymmetric periodic excitation — •Thomas John[1,2], Dirk Pietschmann[2], Ralf Stannarius[2], and Christan Wagner[1] — [1]Universität des Saarlandes, 66123 Saarbrücken — [2]Otto-von-Guericke-Universität Magdeburg, 39016 Magdeburg

The Faraday wave experiment is a paradigm for parametric excitable systems, in particular by periodic accelerations. We investigated the onset of the patter formation by periodic, however time asymmetric wave form shapes in excitation. In that case a new question arises: Does the threshold amplitude of the first instability changes - if the asymmetric periodic waveform is only reversed in time. Simple wave forms like sine or square waves are identical under time reversed transformation and can't lead to an influence of the stability of the system. We present our experimental and theoretical results for the Faraday system. The linear stability analysis derived from the Navier-Stokes equations will discussed for arbitrary periodic wave forms. In addition, a simpler analytical example system with parametric, periodic and time asymmetric driving is presented. In this example: if the shape of the excitation is exclusively time reversed (amplitude is the same) then the stability changes from unstable to stable and vice versa. The reduced complexity in the example system presents the mathematical properties more clear. Nevertheless, the linear stability analysis of the Faraday wave experiment shows a perfect agreement with our experimental obtained results. D. Pietschmann, R. Stannarius, C. Wagner and T. John, PRL 110, 094503 (2013).

15 min. break

DY 44.7 Thu 11:15 BH-N 333

On the self-assembly of magnetic cubes - infinite frustration bears a sevenfold magnetic clutch — •Ingo Rehberg — Experimentalphysik V, Uni Bayreuth

The self-assembly of magnetic particles into a simple cubic lattice [1] triggers questions like: - Why do they form cuboids,rather than chains or ribbons? - What is the overall magnetization of those clusters? - How susceptible are they to external magnetic fields? - What is the arrangement of the individual magnets within those clusters?

Answers are provided by experimental investigations [1] and calculations based on dipole-dipole interaction of magnetic particles [2]. The minimal arrangement consisting of eight dipoles arranged in the corners of a cube bears a continuum of dipoles arrangements as the ground state, suggesting a seven-fold magnetic clutch operating smoothly in the flat potential valley of this goldstone mode.

[1] S. Mehdizadeh Taheri, S. Rosenfeldt, M. Michaelis, M. Drechsler, B. Förster, P. Böseke, T. Friedrich, I. Rehberg, and S. Förster, in preparation.

[2] J. Schönke, T. Schneider, and I. Rehberg, in preparation.

DY 44.8 Thu 11:30 BH-N 333

The tongue as an excitable medium — •Gabriel Seiden[1,2] and Sofia Curland[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden 01187 — [2]Weizmann Institute of Science, Rehovot 76100, Israel

Geographic tongue (GT) is a medical condition affecting approximately 2% of the population, whereby the papillae covering the upper part of the tongue are lost due to a slowly expanding inflammation. The resultant dynamical appearance of the tongue has striking similarities with well known out-of equilibrium phenomena observed in excitable media, such as forest fires, cardiac dynamics and chemically driven reaction-diffusion systems. We explore the dynamics associated with GT from a dynamical systems perspective, utilizing cellular automata simulations. Our results shed light on the evolution of the inflammation and suggest a practical way to classify the severity of the condition, based on the characteristic patterns observed in GT patients.

DY 44.9 Thu 11:45 BH-N 333

Homoclinic snaking near the surface instability of a polarizable fluid — •David J.B. Lloyd[1], Christian Gollwitzer[2], Ingo Rehberg[2], and Reinhard Richter[2] — [1]Department of Mathematics, Univ. of Surrey, Guildford, GU2 7XH, UK — [2]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth, Germany

We report on localized patches of cellular hexagons observed on the surface of a magnetic fluid in a vertical magnetic field. These patches are spontaneously generated by jumping into the neighborhood of the unstable branch of the domain covering hexagons of the Rosensweig instability. They are found to co-exist in intervals around this branch. We derive a general energy functional for the system and a corresponding Hamiltonian that provides a pattern selection principle allowing us to compute Maxwell points for general magnetic permeabilities. Using numerical continuation techniques we investigate the existence of localized hexagons in the Young-Laplace equation coupled to the Maxwell equations. We find cellular hexagons possess a Maxwell point where the energy of a single hexagon is equal to the energy of the flat state providing an energetic explanation for the multitude of measured hexagon patches. Furthermore, it is found that planar hexagon fronts and hexagon patches undergo homoclinic snaking corroborating the experimentally detected intervals.

DY 44.10 Thu 12:00 BH-N 333

Rupture dynamics of liquid crystal bubbles — •Torsten Trittel and Ralf Stannarius — Otto-von-Guericke Universität, Magdeburg, Germany

Several organic liquid materials are able to form stable free standing films. A famous example is the formation of soap bubbles. They are more or less stable objects, until the film is sufficiently disturbed, e.g. when it is punctured. Then, the whole structure becomes unstable and the bubble bursts. We investigate the rupture dynamics of bubbles made from different thermotropic liquid crystal materials by means of high speed imaging. In contrast to soap films, our smectic films have a complete different inherent structure. This structure allows to generate homogeneous films with very low thickness. Furthermore liquid crystal films are stable for days, without drainage or evaporation. In our study, we puncture liquid crystal bubbles with film thicknesses of between 10nm and 300 nm and diameters of about 15 mm. We focus on rupture velocities and the destabilization of the retracting rim into filaments.