DY 21: Pattern Formation

Time: Wednesday 15:00–18:00 Location: HÜL 186

DY 21.1 Wed 15:00 HÜL 186

Pattern selection in liquid crystal growth — •Martin von Kurnatowski and Klaus Kassner — Otto-von-Guericke-University Magdeburg, Department of Theoretical Physics, Universitätsplatz 2, 39106 Magdeburg

The interface of a smectic liquid crystal growing in its undercooled nematic phase forms dendritic patterns. The problem can be described by a simple symmetric diffusion model. In the case of liquid crystals heat transport is anisotropic. However, anisotropic surface tension is required to stabilize the pattern and determine its length scale. The growth is faster in the direction of less efficient heat transport ("inverted growth"). Any physical solution should include this feature.

The solution is derived from an expansion about the case without capillary effects. Including anisotropic surface tension yields an eigenvalue problem for the growth mode. We solve this selection problem of dendritic growth in anisotropic diffusion using the method presented by us in [1]. The length scale is predicted and a quantitative description of the inverted growth phenomenon is given.

[1] M. von Kurnatowski et al., Phys. Rev. E 87 042405 (2013)

DY 21.2 Wed 15:15 HÜL 186

Orientational selection in pattern formation by traveling modulations — •Lisa Rapp[1], Vanessa Weith[1], Alexei Krekhov[1,2], and Walter Zimmermann[1] — [1]Theoretische Physik, 95440 Universität Bayreuth, Germany — [2]Max-Planck-Institut für Dynamik und Selbstorganisation, 37077 Göttingen, Germany

Often disordered stripe patterns occur in two-dimensional isotropic systems, such as in reaction diffusion systems, in thermal convection or in block copolymers. We suggest an effective approach to control the pattern morphology by applying a traveling long-wave periodic modulation of the control parameter of the pattern forming system. The model systems we investigate include the Swift-Hohenberg, the evolution equation for microphase separation in symmetric diblock copolymers and the Lengyel-Epstein model for chemical reactions. Studying the onset of the stripe phase we find that depending on the traveling velocity v different orientations of the stripes with respect to the modulation may be favoured near threshold. In case of a stationary modulation the wave vector of the stripes is preferentially perpendicular to the wave vector of the forcing. This also holds for velocities smaller than a velocity v1. For velocities larger than a velocity v2 a parallel orientation of the wave vectors has the lowest threshold. In the intermediate range v1 < v < v2 both wave vectors adjust themselves at an angle between 0 and $\pi/2$.

DY 21.3 Wed 15:30 HÜL 186

The two-dimensional Kuramoto-Sivashinky equation generalized by a linear and a quadratic damping term — •Marc Osthues, Christian Diddens, and Stefan J. Linz — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster

Inspired by the effect of particle redeposition in the context of self-organized pattern formation on ion-beam eroded semiconductor targets [1,2], we investigate a generalization of the two-dimensional Kuramoto-Sivashinky equation by additionally considering a linear and a quadratic damping/stabilization term. The analysis of the resulting equation by numerical simulations, amplitude equations and Galerkin approximations reveals a variety of solution types depending on the entering parameters. The arising morphologies range from spatio-temporal chaotic dynamics and blinking states to hexagonally arranged dot and hole patterns as well as ripple structures [3].

[1] C. Diddens and S. J. Linz, EPL, 104 (2013) 17010
[2] C. Diddens and S. J. Linz, Eur. Phys. J. B, 86 (2013) 397
[3] M. Osthues, C. Diddens and S. J. Linz, (in preparation)

DY 21.4 Wed 15:45 HÜL 186

Collective behaviour of shifted dipoles in external fields — •Arzu Bahar Yener and Sabine H. L. Klapp — Hardenbergstr. 36, 10623 Berlin, Germany

A colloidal system of spherical particles with centred dipolar mo- ments show self-organisation to layered structures in the presence of an external rotating magnetic field [1]. This non-equilibrium phenomenon requires synchronised motion of the particles with each other and with the driving field [1].

We investigate a model system of spherical particles carrying permament dipole moments shifted out of the centres of mass and interacting by a soft core potential and a point dipole potential. Such system can be used to model experimentally created particles with magnetic caps [2] or Janus particles [3]. We aim to describe the non-equilibrium behaviour of the system in external rotating magnetic fields, using molecular dynamics simulations. We present groundstate structures of the shifted dipolar system as well as simulation results in the presence or absence of external magnetic fields. [1] S. Jäger, and S. H. L. Klapp, Soft Matter 7, 6606 (2011) [2] D. Zerrouki, J. Baudry, D. Pine, P. Chaikin, and J. Bibette, Nature 455, 380 (2008) [3] J. Yan, M. Bloom, S. C. Bae, E. Luijten, and S. Granick, Nature 491, 578 (2012)

DY 21.5 Wed 16:00 HÜL 186

Phase separation by Marangoni flow drives active droplet — •Max Schmitt and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin, Germany

One possible design of a spherical microswimmer is a water droplet in an oil phase with surfactants at the interface [1]. Bromine inside the droplets catalyzes a reaction, which saturates the double bond in the surfactant molecule, making it a weaker surfactant with a higher surface tension. The resulting binary mixture of surfactants will then demix due to Marangoni flow, initiated by and directed along a surface tension gradient. Thus a so-called squirmer results, which reaches a steady swimming state, when the surface is covered with only two domains that cannot demix any further.

We have extended our recently developed model based on a reaction-advection-diffusion equation for the surfactant mixture on an axisymmetric sphere [2], by considering a sphere without axisymmetry and by adding thermal noise. This allows us to trace back the random walk of the squirmer visible in its swimming trajectory to local fluctuations in the surfactant mixture. Furthermore, we investigate the time-dependence of the coarsening dynamics of the surfactant mixture and compare it to results from the classical Cahn-Hilliard theory for phase separation.

[1] Thutupalli S. *et al New J. Phys.* **13** 073021 (2011)
[2] Schmitt M. and Stark H., *Europhys. Lett.* **101** 44008 (2013)

DY 21.6 Wed 16:15 HÜL 186

Pattern formation in anisotropic systems with modulation: stripes versus defects — •Badr Kaoui, Achim Guckenberger, Falko Ziebert, Alexei Krekhov, and Walter Zimmermann — Theoretical Physics I, University of Bayreuth, 95440 Bayreuth, Germany

A new symmetry class of pattern formation is investigated, having an anisotropy direction and a modulation perpendicular to the former. An example for this situations is the wrinkle pattern that forms during the relaxation of a deposited thin solid film (e.g. oxide) on a stretched soft substrate (e.g. a PDMS elastomer). If the substrate elastic properties are anisotropic perpendicular to the direction of prestretching, beyond a critical modulation strength, a fascinating competition occurs between the emergence of perfect regular stripes and wrinkles including branching defects. Using pseudo-spectral simulations and linear stability analysis we show how spatial modulations induce a wave-number band of patterns including various defect orders. We found unexpectedly the existence of a band of stable defect free stripe patterns and we predicted when and how these stripes bifurcate from the defect and flat ground states. Related universal phase diagrams are drawn with possible applications to the wrinkles system and the dissipative counterpart of the electroconvection in nematic liquid crystals.

15 min break

DY 21.7 Wed 16:45 HÜL 186

Mode transitions of oscillating water drops — •Frank Rietz and Stefan C. Müller — University of Magdeburg, Institute of Experimental Physics, Pattern Formation Group

Drop oscillations occur, for example, in the rain and play a role in technological processes. The process by which a pollutant is incorporated into a rain drop depends on its shape, which changes drastically during the oscillation. Such oscillations are easily observed, if water is poured on a hot plate. At sufficiently high plate temperature the drop floats on its own steam film. The thin sheet thermally insulates the liquid and the drop survives for several minutes (Leidenfrost-effect). During the evaporation process the drop oscillates in different eigenmodes that resemble star-like shapes. The modes of the star-shaped drops spontaneously change in irregular periods. For evaporating drops on a hot plate we measure the relation between mode change, drop size, and oscillation period. Experiments are performed at shrinking and constant drop volume.

DY 21.8 Wed 17:00 HÜL 186

Cracking over patterned substrates — •Pawan Nandakishore, Anupam Sengupta, and Lucas Goehring — Max Planck Institute for Dynamics and Self-Organization (MPIDS) 37077 Göttingen, Germany

From thermal cracks on the surface of Mars to desiccation cracks in dried paint, cracking occurs at all length scales. In the above examples the substrate structure influences the resulting crack pattern. We study the effect of the substrate by generating desiccation cracks on patterned substrates over various length scales. On the macro (decimeter) scale, we dry Bentonite slurries over sinusoidal substrates and study them using time lapse photography. The wavelength, amplitude of the substrate and the layer height of the clay are the relevant parameters. We use an orientational order parameter to characterize the crack pattern. We find that the order parameter evolves nonmonotonically with layer height which hints that when the layer height is comparable to the wavelength there is roughly a crack on top of every peak, such a pattern is characterized by a high order parameter. We fabricate sinusoidal substrates on the micro scale by oxidizing thin films of PDMS under strain. We deposit Bentonite, laponite and other colloidal suspensions on the patterned PDMS substrates and study their drying and cracking behavior. Combining observations at both length scales we attempt to decipher what lies beneath a crack pattern.

DY 21.9 Wed 17:15 HÜL 186

Roles of pattern competition in diversity-induced resonance — •Miriam Grace and Marc-Thorsten Hütt — Jacobs University Bremen, Bremen, Germany

The phenomenon of diversity-induced resonance, in which a system's response is enhanced at intermediate parameter disorder, has been studied for several years in wide-ranging contexts. We previously used an event-based view to understand developmental paths to spatiotemporal patterns [1,2]. We here explore the mechanisms of diversity-induced resonance in FitzHugh-Nagumo lattices, analyzing the competitive interactions between spiral and target wave events subject to differing levels of diversity [3]. We use minimal-ingredient lattices to understand how the diversity parameters control aspects of these competition scenarios. This form of diversity-induced resonance arises from different types of pattern competition: frequency-based interactions of target and spiral waves, and competition determined by the properties of parameter distributions. The resonance responses of wave counts to diversity are statistically controlled by the number of oscillatory elements in the lattice, rather than by the frequency differences between target and spiral waves.

1. Geberth, D. and Hütt, M.-Th (2009) PloS Comput. Biol. 5, doi: 10.1371/journal.pcbi.1000422
2. Grace, M. and Hütt, M.-Th. (2013). J. R. Soc. Interface 10, doi: 10.1098/rsif.2012.1016.
3. Grace, M. and Hütt, M.-Th (submitted). Eur. Phys. J. B.

Invited Talk DY 21.10 Wed 17:30 HÜL 186

Episodic Precipitation — •Jürgen Vollmer — Max Planck Institute for Dynamics and Self-Organization (MPI DS), 37077 Göttingen, Germany — Faculty of Physics, Georg August University, 37077 Göttingen, Germany

Episodic outbreaks with potentially catastrophic consequences are characteristic of geysers, as well as lake, oceanic and volcano eruptions. These processes have in common that a slow continuous mass or heat flux into a fluid mixture leads to slow bubble growth, and that episodically the material accumulated in the bubbles is released in explosive precipitation events. The slow growth of the bubbles in response to the flux involves phase separation and ripening. Indeed, periodic modulations of precipitation rates arise also in laboratory experiments where phase separation in binary fluids is monitored during a temperature ramp.

To gain insight into the origin of this episodic precipitation, I revisit the evolution of the droplet size distribution. The net flux to the droplets constitutes an essential perturbation to the Lifshitz-Slezov-Wagner scenario of zero flux. Any finite flux leads to qualitatively different growth laws. Accounting for these differences, I provide a quantitative description of the time scale, Δt, separating subsequent outbreaks in our experiments.