DY 83: Pattern Formation II

Time: Friday 10:00–12:15 Location: BH-N 333

DY 83.1 Fri 10:00 BH-N 333

Fast propagation regions of a specific geometry can cause reentry in excitable media — •Vladimir Zykov, Alexei Krekhov, and Eberhard Bodenschatz — Max Plank Institute for Dynamics and Self-Organization, Goettingen, Germany

Many theoretical and experimental studies indicate that a propagation block represents an important factor in spiral wave initiation in excitable media. The analytical and numerical results we obtained for a generic two-component reaction-diffusion system demonstrate quantitative conditions for the propagation block in a one-dimensional and a two-dimensional medium due to a sharp spatial increase of the medium's excitability or the coupling strength above a certain critical value. Here we prove that this critical value strongly depends on the medium parameters and the geometry of the inhomogeneity. For an exemplary two-dimensional medium we show how the propagation block can be used to initiate spiral waves by a specific choice of the size and shape of the medium's inhomogeneity.

DY 83.2 Fri 10:15 BH-N 333

Wave propagation in spatially modulated domains — •Steffen Martens, Alexander Ziepke, and Harald Engel — Technische Universität Berlin, Institut für Theoretische Physik, 10623 Berlin, Germany

Propagation of traveling wave patterns plays in crucial role in various technological and biophysical processes such as catalysis, CO_2 sequestration, chemical computing, neural information processing, and self-organized pattern formation in cells. Often, the medium supporting wave propagation exhibits an irregular shape and/or is limited in size, leading to complex wave phenomena.

Recently [S. Martens et al., PRE **91**, 022902; JCP **145**, 094108], we have provided a first systematic treatment by applying asymptotic perturbation analysis leading to an approximate description that involves a reduction of dimensionality; the 3D RD equation with spatially dependent no-flux boundary conditions on the reactants reduces to a 1D reaction-diffusion-advection equation. Numerical simulations demonstrate that our analytical results predict properly the nonlinear dependence of the propagation velocity on the ratio of the period of the cross-section's spatial modulation to the intrinsic width of the wave solution. As a main feature, we observe finite intervals of propagation failure of waves induced by the tube's modulation.

Proofing the assumptions made in our analytic approach, we perform experiments on the propagation of traveling pulses in the Belousov-Zhabotinsky reaction through sinusoidal modulated channels being milled into acryl glas.

DY 83.3 Fri 10:30 BH-N 333

Front propagation in agitated wet granular matter — Andreas Zippelius and •Kai Huang — Experimentalphysik V, University of Bayreuth, 95440 Bayreuth, Germany

Abstract: From sand dunes to Faraday heaping, granular materials (i.e. large agglomeration of macroscopic particles) are rich pattern forming systems. When the particles are partially wet (e.g. wet sand on the beach), a different pattern forming scenario arises due to cohesion: Kink-wave fronts were found to be the dominating pattern [1]. Here, we focus on the formation of density-wave fronts in an oscillated wet granular layer undergoing a gas-liquid-like transition [2]. The threshold of the instability is governed by the amplitude of the vertical vibrations. Fronts, which are curved into a spiral shape, propagate coherently along the circular rim of the container with leading edges. They are stable beyond a critical distance from the container center. Based on the measurement of the critical distance and the rotation frequency, we propose a model for the pattern formation by considering the competition between the time scale for the collapse of cohesive particles and that of the energy injection resisting this process.

[1] Butzhammer, L., Völkel, S., Rehberg, I. & Huang, K. *Phys. Rev. E* 92, 012202 (2015).
[2] Zippelius, A. & Huang, K. *Sci. Rep.* 7, 3613 (2017)

DY 83.4 Fri 10:45 BH-N 333

Structuring of the epithelial tissue — •Jakov Lovrić[1], Michael A. Klatt[2], Sara Kaliman[3], Gerd E. Schröder-Turk[4,5], and Ana-Sunčana Smith[3] — [1]Division of Physical Chemistry, Ruđer Bošković Institute, Zagreb, Croatia — [2]Karlsruhe Institute of Technology (KIT), Institute of Stochastics, Karlsruhe, Germany — [3]PULS Group, Institut für Teoretische Physik and EAM Cluster of Exellence, FAU Erlangen-Nürnberg, Erlangen, Germany — [4]Institut für Teoretische Physik, FAU Erlangen-Nürnberg, Erlangen, Germany — [5]Murdoch University, School of Engineering and IT, Murdoch, Australia

Structural properties of space tessellations are important to understand various problems in many fields of science and industry. One of the existing questions is how to tessellate space with the maximized centrality of the cells, usually known as Quantizer problem. Here we study stable solutions of Quantizer problem by applying Lloyd's algorithm on various disordered random point processes. We find that Lloyd's algorithm converges to a universal amorphous structure with a long-range order. Furthermore, we investigate the role of cell centrality in the epithelium tissue. First, we find that the tissue can be represented by the tessellation based on the nuclear shape of constituting cells. In the following, we explore the interplay between finite size effects and the Lloyd minimisation and find that during the epithelial tissue development, centrality as a concept may play a role and is tightly controlled by the activity of the cell.

15min. break

DY 83.5 Fri 11:15 BH-N 333

Influence of additive noise on spatially one- and two-dimensional localized structures in the Kuramoto-Sivashinsky-Verhulst equation — •Christoph Kabelitz and Stefan Jakob Linz — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster

In the past years, spatially localized structures in physical systems and mathematical models became popular [1, 2]. While mathematical models are usually deterministic, experiments suffers from noise. We present an analysis concerning the Kuramoto-Sivashinsky-Verhulst equation with additive noise. The model equation is representative for stochastic partial differential equations whose deterministic versions have stable localized structures as solutions. In both, the spatially one- and the spatially two-dimensional case, the localized structures become unstable due to noise. We will show that the average time till a structural change occurs depends primarily on the strength of noise and the distance to the pinning border of the localized structures in the equation's deterministic variant in parameter space.

[1] E. Knobloch, Annu. Rev. Cond. Matter Phys., 6, 325 (2015).
[2] D. J. B. Lloyd et al., SIAM J. on Appl. Dyn. Sys., 7, 1049 (2008).

DY 83.6 Fri 11:30 BH-N 333

Nikolaevskiy turbulence: Development and test of amplitude equations — •Steffen Richters-Finger and Stefan Jakob Linz — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Germany

The Nikolaevskiy equation, originally introduced as a model for seismic waves [1], also appears in many different contexts ranging from instabilities of fronts over electroconvection to reaction-diffusion-systems and serves as a paradigmatic minimal model for the appearance of soft-mode turbulence in most parameter ranges. The known set of amplitude equations describing the chaotic dynamics close to the instability were originally derived by Matthews and Cox [2]. Using Lyapunov exponents, we present an alternative approach for identifying additional scales and test a practical method for the measurement of the qualitative deviation between the full system and its amplitude model.
[1] V. Nikolaevskii, Lecture Notes in Engineering **39**, 210 (1989). [2] P. C. Matthews and S. M. Cox, Phys. Rev. E **62**, R1473 (2000).

DY 83.7 Fri 11:45 BH-N 333

DNS of the Navier-Stokes equations — •Sebastian Richter and Michael Bestehorn — Department of Theoretical Physics, BTU, 03044, Cottbus, Germany

We present a numerical method for free-surface problems of the Navier-Stokes equations under external excitation. The evolution of a two-dimensional fluid layer on a vibrating substrate is considered. Based on

the nonlinear transformation $z = h(x,t) \cdot \tilde{z}$ of the vertical coordinate, we derive an algorithm that pares the required interpolations down to the minimum. The results of our simulations show good agreement with the lubrication-approximation-based model investigated in [1] and [2].

[1] M. Bestehorn, "Laterally extended thin liquid films with inertia under external vibrations", Phys. Fluids 25, 114106 (2013)
[2] S. Richter and M. Bestehorn, "Thin-Film Faraday patterns in three dimensions", Eur. Phys. J. Special Topics 226, 1253-1261

DY 83.8 Fri 12:00 BH-N 333

A Tower of Scales in Ensemble Modeling: Order, Disorder, Fusion — Antonina N. Fedorova and •Michael G. Zeitlin — Russia, 199178, St.Petersburg, V.O. Bolshoj pr., 61, IPME RAS, Mathematical Methods in Mechanics Group

A fast and efficient numerical-analytical approach is proposed for the description of complex behaviour in non-equilibrium ensembles both in the BBGKY framework and in a number of its (Vlasov-Poisson/Maxwell-like) reductions. We construct a multiscale representation for the hierarchy of partition functions by means of the variational approach and multiresolution decomposition. Modeling shows the creation of various internal structures from fundamental localized (eigen)modes. These patterns determine the behaviour of ensembles. The Waveleton, localized (meta) stable long-living pattern with minimal entropy and zero measure, is proposed as a possible model for the energy confinement state (the fusion state) in plasma.