DY 23: Reaction-Diffusion Systems

Time: Tuesday 14:30–16:15 Location: BH-N 243

DY 23.1 Tue 14:30 BH-N 243

Front and Turing patterns induced by Mexican-hat-like nonlocal feedback. — •Julien Siebert and Eckehard Schöll — Technische Universität, Berlin, Deutschland

We consider the effects of a Mexican-hat-shaped nonlocal spatial coupling, i.e., symmetric long-range inhibition superimposed with short-range excitation, upon front propagation in a model of a bistable reaction-diffusion system. We show that the velocity of front propagation can be controlled up to a certain coupling strength beyond which spatially periodic patterns, such as Turing patterns or coexistence of spatially homogeneous solutions and Turing patterns, may be induced. This behaviour is investigated through a linear stability analysis of the spatially homogeneous steady states and numerical investigations of the full nonlinear equations in dependence upon the nonlocal coupling strength and the ratio of the excitatory and inhibitory coupling ranges.

DY 23.2 Tue 14:45 BH-N 243

Front propagation in channels with spatially modulated cross-section — •Steffen Martens, Jakob Löber, and Harald Engel — Technische Universität Berlin, Berlin, Germany

The problem of front propagation in a three-dimensional channel with spatially varying cross-section is reduced to an equivalent reaction-diffusion-advection equation with boundary-induced advection term [S. Martens et al.,*PRE*, in press; arXiv:1406.7516]. Treating the advection term as a weak perturbation, an equation of motion for the front position is derived. We analyze channels whose cross-sections vary periodically with L along the propagation direction of the front. Taking the Schlögl model as representative example, we calculate analytically the nonlinear dependence of the front velocity on the ratio L/l where l denotes the intrinsic front width. Our analytical results agree well with the results obtained by numerical simulations. In particular, the peculiarity of boundary-induced propagation failure for a finite range of L/l values is predicted by analytical calculations. Lastly, we demonstrate that the front velocity is determined by the suppressed diffusivity of the reactants for $L \ll l$.

DY 23.3 Tue 15:00 BH-N 243

Kinetics of a chemical clock reaction in a microflow — •Robert Raimund Niedl[1], Alexander Anielski[1], Igal Berenstein[2], and Carsten Beta[1] — [1]Biological Physics, Universität Potsdam, Germany — [2]Nonlinear Physical Chemistry Unit,Université libre de Bruxelles, Brussels

We study the dynamics of the autocatalytic iodate-arsenite reaction in PDMS-based microfluidic devices under continuous flow conditions. If a critical amount of initializer is present, a color reaction is triggered by a nonlinear autocatalytic process. We investigate the kinetics of the clock depending on the various input concentrations and in different channel geometries. We could show that due to delayed mixing in the microchannel, higher local initiator concentrations occur, so that the reaction runs up to seven times faster, than in a macroscopic well-mixed volume.

DY 23.4 Tue 15:15 BH-N 243

Three-Dimensional Autonomous Pacemaker in Excitable Media — •Arash Azhand, Jan F. Totz, and Harald Engel — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

In experiments with the photosensitive Belousov-Zhabotinsky reaction (PBZR) we found a stable three-dimensional organizing center that periodically emits trigger waves of chemical concentration. Our experiments are performed in a parameter regime with negative line tension using an open gel reactor to maintain stationary non-equilibrium conditions. The observed periodic wave source is formed by a scroll ring stabilized due to its interaction with a no-flux boundary.

Sufficiently far from the boundary, the scroll ring expands and undergoes the negative line tension instability before it finally develops into scroll wave turbulence. Our experimental results are reproduced by numerical integration of the modified Oregonator model for the PBZR. In the numerical simulations besides stationary also breathing self-organized pacemakers have been found where both the radius of the scroll ring and the distance of its filament plane to the no-flux boundary undergo stable limit cycle oscillations.

[1] Y. Kuramoto, Chemical Oscillations, Waves, and Turbulence (Dover Publications, 2003)

[2] M. Stich, I. Ipsen, and A.S. Mikhailov, Phys. Rev. Lett. 86, 4406 (2001)

[2] A. Azhand, J. F. Totz, and H. Engel, EPL 108, 10004 (2014)

DY 23.5 Tue 15:30 BH-N 243

Critical coupling and bifurcations in two-dimensional oscillator arrays undergoing the Belousov-Zhabotinsky reaction — •Claudia Lenk and J. Michael Köhler — Institut für Chemie und Biotechnologie, TU Ilmenau, Ilmenau, Deutschland

Spatio-temporal dynamics of many biological and chemical systems depend on coupling of individual oscillators e.g. catalyst particles, the heart cells during atrial fibrillation or neuronal networks. In these systems, irregular patterns and bifurcations of frequency are most often observed in regions of critical coupling strength. To elucidate the influence of local coupling of individual oscillators we perform on one hand experiments of the Ferroin-catalyzed Belousov-Zhabotinsky reaction in silica gels and on the other hand numerical calculations of the FitzHugh-Nagumo (FHN) model, both with a catalyst distribution in form of a micro spot pattern. We observe transitions to multiple period oscillations and amplitude oscillations in dependence of spot distance and size. Furthermore, these transitions can also be observed due to gradients of the spot distance for parameter ranges, which otherwise do not show these bifurcations. The identifiation of bifurcation parameters is done in the numerical simulations. Experimental results confirm the numerical analysis.

DY 23.6 Tue 15:45 BH-N 243

Electrodissolution of silicon: Self-organized patterns in space and time — •Konrad Schönleber, Lennart Schmidt, and Katharina Krischer — TU München, Deutschland

The oscillatory electrodissolution of silicon in fluoride containing electrolytes has been studied for decades. Still many basic aspects concerning this system remain unknown, most prominently the mechanism giving rise to the oscillations.

In the present work, some key features of this oscillatory mechanism will be presented. It will be secifically shown that the system seems to have a built-in memory of its current state even when perturbed drastically.

For n-doped silicon, pattern formation is observed under limited illumination. Remarkably, these patterns often consist of different dynamical states coexisting on the electrode, the most striking example of which are the so-called 'chimera states'. The pattern formation can be well understood in theory, when treating the silicon as an oscillatory medium close to the onset of oscillations. A comparison of theoretical simulations and experiments will be given.

DY 23.7 Tue 16:00 BH-N 243

Enhancement of dimerization in a 1D-out-of-equilibrium system — •Philipp Seifert[1,2], Patrick Hillenbrand[2], Vladimir Palyulin[2], and Ulrich Gerland[2] — [1]Ludwig-Maximilians-Universität München, 80799 Munich, Germany — [2]Theory of Complex Biosystems, Physik-Department, Technische Universität München, James-Franck-Strasse 1, D-85748 Garching, Germany

Mutual enhancement of polymerization and accumulation was recently found to be essential for spontaneous synthesis of long polynucleotides from nucleotide monomers, which is perceived as a substantial step in the emergence of early life [1]. The major driving force behind this effect is a thermally induced drift, which increases the concentration of monomer units in a certain volume and hence enhances the subsequent polymerization. Here we study a simple model of a drift-diffusion system coupled with a reversible dimerization process. We introduce a measure of the global chemical balance, which characterizes the enhancement of dimerization relative to a homogenous system. Numerical and analytical results show a nontrivial dependence of this enhancement on the physical properties of the system. Specifically, we find that the ratio of timescales between physical and chemical processes critically influences the steady state properties.

[1] Mast, C. B., Schink, S., Gerland, U., and Braun, D. (2013). Proc. Natl. Acad. Sci. USA, 110, 8030-8035.