# DY 43: Pattern Formation - organized by Azam Gholami (Göttingen)

Time: Wednesday 14:00–16:00 Location: DYa

DY 43.1 Wed 14:00 DYa

**Suppression of coarsening in a Cahn-Hilliard model with nonreciprocal coupling** — •Tobias Frohoff-Hülsmann[1] and Uwe Thiele[1,2] — [1]Institute of theoretical physics, WWU Münster — [2]Center of Nonlinear Science (CeNoS), WWU Münster

When coarsening occurs, an initial patterned state develops into a fully phase-separated state. This is standard for passive mixtures and is now also frequently discussed in the field of active matter. The Cahn-Hilliard equation is the paradigmatic description for a passive system characterized by a single conserved order parameter field, e.g., concentration for a mixture. Here, we study a two-field Cahn-Hilliard system (e.g. representing a ternary mixture). The chosen couplings maintain both conservation laws and consist of passive (reciprocal) and active (nonreciprocal) contributions. Our particular focus is the suppression of coarsening that occurs when going from the passive to the active case. We distinguish three mechanisms of suppression: Linear and nonlinear complete, and nonlinear partial suppression. They differ from the suppression of coarsening due to broken mass conservation observed in other systems.

DY 43.2 Wed 14:20 DYa

**Pattern selection in reaction-diffusion systems** — •Srikanth Subramanian and Seán M. Murray — Max Planck Institute for Terrestrial Microbiology, Marburg, Germany

Turing's theory of pattern formation has been used to describe the formation of self-organized periodic patterns in many biological, chemical, and physical systems. However, the use of such models is hindered by our inability to predict, in general, which pattern is obtained from a given set of model parameters. While much is known near the onset of the spatial instability, the mechanisms underlying pattern selection and dynamics away from onset are much less understood. Here, we provide physical insight into the dynamics of these systems. We find that peaks in a Turing pattern behave as point sinks, the dynamics of which is determined by the diffusive fluxes into them. As a result, peaks move toward a periodic steady-state configuration that minimizes the mass of the diffusive species. We also show that the preferred number of peaks at the final steady state is such that this mass is minimized. Our work presents mass minimization as a potential general principle for understanding pattern formation in reaction diffusion systems far from onset.

DY 43.3 Wed 14:40 DYa

**Periodic patterns displace active phase separation** — •Frederik Thomsen and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth

In this work we identify and investigate a novel bifurcation in conserved systems on one- and two-dimensional spatial domains. This secondary bifurcation stops active phase separation in its nonlinear regime. It is then either replaced by an extended, system-filling, spatially periodic stripe pattern in one spatial dimension or by a hexagonal pattern in two dimensions. In complementary parameter regions phase separation is replaced by a novel hybrid state with spatially alternating homogeneous and periodic states. The transition from phase separation to extended spatially periodic patterns is hysteretic. We show that the resulting patterns are multistable, as they show stability beyond the bifurcation for different wavenumbers belonging to a wavenumber band. Both transition scenarios are systems-spanning phenomena in particle conserving systems. They are predicted with a generic dissipative model as described by this contribution. Candidates for specific systems in which these generic secondary transitions are likely to occur are, for example, generalized models for motility-induced phase separation in active Brownian particles, models for cell division or chemotactic systems with conserved particle dynamics.

DY 43.4 Wed 15:00 DYa

**Chimera solitons and soliton turbulence in oscillatory media** — •Arkady Pikovsky[1], Lev Smirnov[2], Maxim Bolotov[3], Dmitry Bolotov[3], and Grigory Osipov[3] — [1]University of Potsdam, Germany — [2]Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russia — [3]Department of Control Theory, Nizhny Novgorod State University, Nizhny Novgorod, Russia

Chimera states are coexisting patterns of synchrony and asynchrony in oscillatory media. Here we report on stable solitary chimera states in an infinite medium: a finite region of synchrony coexists with an infinite asynchronous background. When this state becomes unstable, soliton turbulence appears, where solitons merge and reappear randomly. With a further change of parameters, this regime evolves into a spatial-temporal intermittency, where the synchronous state is absorbing. Close to the transition point, where the spatial-temporal intermittency disappears, it is dominated by traveling dark solitons: moving patches of asynchrony on a synchronous background.

DY 43.5 Wed 15:20 DYa

**A hierarchy of protein patterns robustly decodes cell shape information** — •Tzer Han Tan[1,4], Manon C. Wigbers[2], Fridtjof Brauns[2], Jinghui Liu[1], Zak Swartz[3], Erwin Frey[2], and Nikta Fakhri[1] — [1]MIT, Cambridge, USA — [2]LMU, Munich, Germany — [3]Whitehead Institute, Cambridge, USA — [4]MPI-CBG, Dresden, Germany

Many cellular processes rely on precise positioning of proteins on the membrane. Such protein patterns emerge from a combination of protein interactions, transport, conformational state changes, and chemical reactions at the molecular level. Recent experimental and theoretical work clearly demonstrates the role of geometry and advective cortical flow in modulating membrane protein patterns. How can regulatory proteins form a robust spatiotemporal organization on the membrane in the face of dynamic cell-shape changes during physiological processes? Here, we use the oocytes of the starfish *Patiria miniata* as a model system and elucidate a shape-adaptation mechanism that robustly controls spatiotemporal protein dynamics on the membrane despite cell-shape deformations. By combining experiments with biophysical theory, we show how cell-shape information contained in a cytosolic gradient can be decoded by a bistable regulator of Rho. In turn, this bistable front precisely controls a mechanochemical response by locally triggering excitable dynamics of Rho. We posit that such a shape-adaptation mechanism based on a hierarchy of protein patterns may constitute a general physical principle for cell-shape sensing and control.

DY 43.6 Wed 15:40 DYa

**Wavelength selection by interrupted coarsening in reaction–diffusion systems** — Fridtjof Brauns[1], •Henrik Weyer[1], Jacob Halatek[2], Junghoon Yoon[1], and Erwin Frey[1] — [1]Arnold Sommerfeld Center for Theoretical Physics and Center for NanoScience, Department of Physics, Ludwig-Maximilians-Universität München, Theresienstraße 37, D-80333 München, Germany — [2]Biological Computation Group, Microsoft Research, Cambridge CB1 2FB, UK

Intracellular pattern formation may be described by (nearly) mass-conserving reaction–diffusion systems. Of these, two-component mass-conserving reaction–diffusion systems are paradigmatic models, also used to describe for example precipitation patterns or granular media systems. We will discuss that these mass-conserving models generically show uninterrupted coarsening because of positive feedback in the mass transport between neighbouring pattern domains. From this, a general coarsening criterion follows and the coarsening law may be determined.

We use this understanding to explain the arrest of coarsening due to weak source terms and predict the wavelength thereby selected. This analysis will exemplify how the phase-space structure of pattern-forming systems may be used to study wavelength selection far from equilibrium.