SYSS 2 Structure Formation and Self-Organization in non-equilibrium Systems II

Time: Thursday 14:30–16:00 Room: BAR Schö

SYSS 2.1 Thu 14:30 BAR Schö

Reading the pattern in living cells - the Physics of Calcium signalling — •Martin Falcke — Abteilung Theorie SF5, Hahn-Meitner-Institut Berlin

Structure formation and self-organization is used inside living cells to transmit signals or to encode a physiological state as we will outline by several examples: The dynamics of periodic wave trains and wave train bifurcations explain the response of cells to energization of mitochondria or overexpression of SERCA-protein. The spatial structure of cells allows for oscillations in a non-oscillatory dynamic regime by repetitive wave nucleation. The talk gives a survey of how living cells transform structure formation far from equilibrium into physiological function.

SYSS 2.2 Thu 14:45 BAR Schö

Nonlinear competition between patterns in filament-motor-systems — •Falko Ziebert and Walter Zimmermann — Theoretische Physik Ia, Universität Bayreuth

Biopolymer systems have various mechanisms for pattern formation. One is the interplay of polymerization and demixing
[1] .

Interaction via molecular motors is a second way and modelled here by a Smoluchowski equation approach. It is shown that the homogeneous distribution of filaments, such as actin or microtubules, may become either unstable with respect to a homogeneous nematic state, to an orientational instability of a finite wave number or with respect to modulations of the filament density, where long wavelength modes are amplified as well. In the stationary case above threshold nonlinear interactions select either stripe patterns or periodic asters
[2] .

The existence and stability ranges of each pattern close to threshold are predicted in terms of a weakly nonlinear perturbation analysis and confirmed by numerical simulations of the basic model equations. Also oscillatory solutions exist and existence and stability of 1D and 2D wave solutions are discussed.

[1] F. Ziebert and W. Zimmermann, Phys. Rev. E **70**, 022902 (2004)
[2] F. Ziebert and W. Zimmermann, Europhys. J. E **18**, 41 (2005)

SYSS 2.3 Thu 15:00 BAR Schö

Scaling regimes in bundling dynamics — •Martin Zapotocky, Peter Borowski, and P. K. Mohanty — Max Planck Institut für Physik komplexer Systeme, Dresden, Germany

We discuss the dynamics of bundling in a population of interacting directed random walks. The model is meant to describe structures formed by the growing axons of peripheral neurons. To account for neural turnover, the random walks are removed and replaced at a fixed rate. Based on numerical simulations, we identify two distinct scaling regimes of the asymptotic dynamics. We investigate analytically the form of the distribution of bundle sizes and the values of growth exponents.

SYSS 2.4 Thu 15:15 BAR Schö

Non-stationary spatial pattern formation in a game-theoretical model — •Robert Mach and Frank Schweitzer — Chair of Systems Design, ETH Zurich, CH-8092 Zurich

Self-organization is a predominant dynamics also in socio-economic systems, where it results from the nonlinear interactions between spatially distributed agents. Each of these agents is driven by internal forces, for example maximizing its private utility. This depends on the interaction with other agents, which is costly. So the whole multi-agent system can only operate in non-equilibrium. The agent's interaction often also leads to the adaptation of a more successful strategy for maximizing the utility. As an example for the interaction we choose a standard example of evolutionary game theory, the iterated prisoner's dilemma (IPD), where 8 different strategies are possible. We are interested in the spatio-temporal distributions of such strategies and the relation to known dynamics of pattern formation in physical systems. We show that the survival of strategies strongly depends on the evolutionary path of the system, i.e. on local conditions. This may lead to different attractors, characterized by different pools of strategies. While the frequencies remain stable, they may still show non-stationary patterns. We further investigate the local conditions that trigger the dynamics towards these different attractors.

SYSS 2.5 Thu 15:30 BAR Schö

Traveling ion channel density waves affected by a conservation law — •Ronny Peter and Walter Zimmermann — Theoretische Physik Ia, Universität Bayreuth, D-95440 Bayreuth

A model of mobile, charged ion channels embedded in a biomembrane is investigated. The ion channels fluctuate between an opened and a closed state according to a simple two-state reaction scheme whereas the total number of ion channels is a conserved quantity. Local transport mechanisms suggest that the ion channel densities are governed by electrodiffusion-like equations that have to be supplemented by a cable-type equation describing the dynamics of the transmembrane voltage. It is shown that the homogeneous distribution of ion channels may become unstable to either a stationary or an oscillatory instability. The nonlinear behavior immediately above threshold of an oscillatory bifurcation occuring at finite wave number is analyzed in terms of amplitude equations. Due to the conservation law imposed on ion channels large-scale modes couple to the finite wave number instability and have thus to be included in the asymptotic analysis near onset of pattern formation. A modified Ginzburg-Landau equation extended by long-wavelength stationary excitations is established and it is highlighted how the global conservation law affects the stability of traveling ion channel density waves.

SYSS 2.6 Thu 15:45 BAR Schö

Travelling wave forcing of Turing structures — •Sten Rüdiger — Hahn-Meitner Institut, Abt Sf5, Glienicker Str. 100, 14109 Berlin

We study domain walls in pattern forming systems of Turing type that are externally forced by a periodic pattern, which is close to spatial resonance of 2:1 (the period of the forcing being half of the internal wavelength) and moving perpendicular to the stripes. Two transitions are identified: A transition where the pattern lags behind the forcing as the forcing becomes too fast and a spontaneous symmetry-breaking transition of walls.

The departure from perfect spatial resonance renders the kink bifurcation imperfect and causes the walls to drift. We study the velocity of the kinks, which behaves strongly nonlinear close to the transitions. A phase approximation is used to analyze the behavior and is valid in a large range of parameters. Results from the phase equation can be generalized to hold for different ratios n:1.