Workshop schedule

Monday, July 27

time	name	location
08:30 - 09:00	Registration	Hall
09:00 - 09:30	Antonia Diana	Humboldtkabinett
09:30 - 10:00	Lara Theallier	
10:00 - 11:00	coffee break	
11:00 - 11:30	Anna Kubin	
11:30 - 12:00	Gianna Götzmann	
12:00 - 13:30	lunch break	
13:30 - 14:30	Barbara Zwicknagl	Humboldtkabinett
14:30 - 15:00	Eugenia Franco	
15:00 - 15:30	coffee break	
15:30 - 16:00	Giulia Cavalleri	
16:00 - 16:30	Erica Ipocoana	
19:00 -	conference dinner	

Tuesday, July 28

time	name	location
09:00 - 09:30	Anastasiia Hrabovets	Humboldtkabinett
09:30 - 10:00	Oleksandra Vinnichenko	
10:00 - 11:00	coffee break	
11:00 - 11:30	Yu Wang	
11:30 - 12:00	Oksana Satur	
12:00 - 13:30	lunch break	
13:30 - 14:30	Katarina Hopf	Humboldtkabinett
14:30 - 15:00	Sophie Gehricke	
15:00 - 15:30	coffee break	
15:30 - 16:00	Iryna Kuznietsova	
16:00 - 16:30	Oleksandra Lokaziuk	
17:00 - 19:00	roundtable discussion	Humboldtkabinett

Giulia Cavalleri

(WIAS Berlin)

On a nonisothermal tumor growth model of Caginalp type

We study an optimal control problem for a nonisothermal phase-field system of Caginalp type that describes tumor growth under thermal therapy. The model couples a possibly viscous Cahn—Hilliard equation, governing the evolution of the healthy and tumor phases, with an equation for the heat balance, and a reaction-diffusion equation for the nutrient concentration. The resulting nonlinear system incorporates chemotaxis and active transport effects, and hyperthermia appears as a control variable. Well-posedness for the initial-boundary value problem and additional regularity are proven. Then, we define a suitable cost functional and show the existence of optimal controls. Finally, we analyze the differentiability of the control-to-state operator and establish a necessary first-order condition for treatment optimality. These results have been obtained in collaboration with Pierluigi Colli (University of Pavia) and Elisabetta Rocca (University of Pavia).

Antonia Diana

(Università di Trento)

Flat Flows of Periodic Lipschitz Subgraphs for Generalized Nonlocal Perimeters

We prove the existence and the (1/2)-Hölder continuity in time of flat flows for periodic Lipschitz subgraphs, whose evolution is governed by the gradient flow of generalized nonlocal perimeters. Moreover, we prove that half-spaces are global minimizers of the generalized nonlocal perimeters and act as attractors for the dynamics. Our theory covers several generalized perimeters, including fractional and Riesz-type perimeters (defined on entire periodic subgraphs through suitable renormalization procedures) and the Minkowski pre-content.

Eugenia Franco

(Hausdorff Center for Mathematics Bonn)

Critical lack of detailed balance in kinetic proofreading systems

The detailed balance is a property of macroscopic systems that are obtained from an underlying time-reversible microscopic model. It states that each elementary process (for instance each chemical reaction) is in equilibrium with its reverse process.

Even if, at the fundamental level, we expect chemical reactions to satisfy the so-called detailed balance condition, biochemical systems are often modeled by systems of equations for which detailed balance fails. This can be justified if the system is in contact with "reservoirs" that are out of equilibrium. In this talk I will discuss the relation between the detailed balance property and the so-called specificity of the classical Hopfield-Ninio kinetic proofreading system.

Sophie Gehricke

(Humboldt-Universität zu Berlin)

(Dynamic Transport) Regularization for PDE-Constrained Minimization

We investigate optimal control problems for parabolic PDEs where the system state is influenced by a finite sum of moving point sources. Such models occur in applications like stabilization of diffusion processes and the inverse reconstruction of moving particles.

After formulating the abstract framework, we compare two regularization approaches: an (L^2)-based regularization leading to measurable trajectories, and an optimal transport-inspired regularization promoting smooth and physically meaningful trajectories.

To solve the resulting problems, we adapt a generalized conditional gradient method that exploits the geometric structure of the regularizers. Numerical examples illustrate applications to inverse problems.

Gianna Götzmann

(University of Augsburg)

Perturbed Minimizing Movements of Time-Dependent Functionals on Metric Spaces

Minimizing movement schemes are a fundamental tool for approximating evolution equations that have a gradient-flow structure with respect to an energy or entropy functional $\mathscr{F}$. Motivated by homogenization problems involving, for instance, a geometry that evolves in time, we consider perturbations of the functional in the sense of a Γ-converging sequence $\mathscr{F}_\varepsilon$, as well as a time dependence. Accordingly, our minimizing movement scheme includes a time discretization $\mathscr{F}_{\varepsilon,\tau,n}$, $n = 1,\ldots,N$, of $\mathscr{F}_\varepsilon$ where N is the number of time steps and τ is the step size. We study the case where ε and τ tend to 0 simultaneously and establish sufficient conditions ensuring the commutativity of the limits. This is joint work with Jan-Frederik Pietschmann and Antonio Tribuzio.

Katarina Hopf

(WIAS Berlin)

Renormalised solutions for entropy-dissipating reaction-diffusion systems with interface conditions

Reaction-diffusion systems dissipating a Boltzmann entropy functional arise in the thermodynamic modelling of various chemical and biological processes. A key difficulty in their analysis stems from the absence of a maximum principle: the available a priori estimates typically do not guarantee integrability of the nonlinear reaction rates, thereby obstructing a distributional formulation. While for pure bulk processes, global existence and weak-strong uniqueness has been obtained by J. Fischer via a concept of renormalised solutions, a comparable theory for reaction-diffusion systems with bulk-interface interactions is not available. In this talk, we consider entropy-dissipating reaction-diffusion systems posed on two bulk domains coupled by transmission conditions at a common interface. We devise a renormalisation procedure adapted to the interfacial coupling, based on local extensions across the interface. This allows us to establish global existence of dissipative renormalised solutions by suitably exploiting the underlying entropic structure. By means of a nonlocal truncated version of the relative entropy, we further establish weak-strong uniqueness of such solutions.
The talk is based on joint work with Bao Quoc Tang.

Anastasiia Hrabovets

(National Academy of Sciences of Ukraine)

Kuramoto-type model for energy optimization in frustrated spin systems

We study a gradient oscillator model that captures the collective dynamics and energy landscape of frustrated spin systems. The model belongs to the Kuramoto class and is defined on a ring with competing nearest- and next-nearest-neighbor interactions. The ring's symmetry translates into a circulant coupling matrix, which offers a convenient analytical setting for investigating the various collective regimes and their stability. A substantial part of the work focuses on the high degree of multistability exhibited by the system. Because of the frustrated couplings, numerous equilibria coexist, ranging from synchronized states, rotating waves, and anti-phase configurations to asymmetric fixed points and whole manifolds of equilibria. The high multistability of this system varies significantly as a result of regular and degenerate bifurcations.
We further analyze how the coupling strength between oscillators shapes the overall energy configuration of the frustrated system, with particular attention to the Maxwell sets. These sets mark the critical parameter values at which a "global" transition takes place, that is, where the global energy minimum switches from one configuration to another. Locating these sets allows us to delineate the boundaries of the energy landscape and to determine which phase configurations are energetically favorable for a given coupling regime. Our findings indicate that, in the thermodynamic limit, the system's behavior is consistent with known results for spin chains under specific boundary conditions. This agreement suggests that the approach may be useful for energy optimization problems in systems with more general or complex structures. This talk is based on joint work with O. Burylko and B. Zwicknagl.

Erica Ipocoana

(Freie Universität Berlin)

Modeling and Analysis of Diffuse Interface Systems Across Biology and Physics

We study diffuse-interface phase-field systems of Cahn-Hilliard and Allen-Cahn type. These models provide a flexible framework for describing a wide range of physical and biological phenomena. In particular, we discuss applications to tumor growth and the dynamics of saline droplets.
Our first aim is the thermodynamically consistent derivation of the governing PDE systems, for which we tailor the strategy to the specific features of each problem. We then address the mathematical analysis of these models, focusing on well-posedness. The main ingredients of the analysis are the construction of suitable discretization schemes, the derivation of a priori estimates, and the passage to the limit to establish the existence of solutions.

Anna Kubin

(TU Wien)

Existence of weak solutions to the Verigin problem with phase transition

In this talk, we study the modeling of a compressible two-phase flow in a porous medium, known as the Verigin problem with phase transition. This evolution can be interpreted as a gradient flow with respect to the 2-Wasserstein distance of a suitable energy.
Motivated by this gradient flow structure, we construct weak solutions to the underlying PDE using the minimizing movement scheme, with the Wasserstein distance as dissipation. More precisely, we show that, in the limit as the time step tends to zero, one obtains distributional solutions that satisfy an optimal energy-dissipation inequality.
This talk is based on joint work with Tim Laux and Alice Marveggio.

Iryna Kuznietsova

(National Academy of Sciences of Ukraine)

Homotopy properties of Morse functions on surfaces

Let M be a smooth compact surface, and let $D(M)$ be the group of diffeomorphisms of M fixing the boundary of M. We consider the natural action of $D(M)$ on the space of smooth functions, under which the result of the action of a diffeomorphism h on a function f is the composition $f \circ h$. The talk is devoted to describing the exact algebraic structure of the fundamental groups of orbits of Morse functions on surfaces. The main result is a complete description of this structure for the Möbius strip.

Oleksandra Lokaziuk

(National Academy of Sciences of Ukraine)

Symmetry analysis of linear systems of second-order ordinary differential equation

The presentation will begin with an introduction to the symmetry analysis of ordinary differential equations. We will review the basic concepts of Lie symmetries and present constructive symmetry tools for the investigation of ordinary differential equations.
We will then present our recent results on the transformation properties of normal linear systems of second-order ordinary differential equations with an arbitrary number of dependent variables. Particular attention will be paid to the structure and classification of their Lie symmetries and to the ways in which these symmetries can be exploited to reduce the order of the systems and their integration. Finally, we will highlight several open problems and promising directions for future research.

Oksana Satur

(National Academy of Sciences of Ukraine)
Attractive interaction in dynamic conflict systems: A mean-field approach

Dynamic conflict systems, introduced by V. Koshmanenko, describe opponents not through their quantities, as in classical Lotka—Volterra models, but through their probability distributions over a resource space partitioned into finitely many positions of conflict. The evolution is governed by a nonlinear conflict composition acting on stochastic vectors, in which the sign of a single parameter separates two archetypes: repulsive interaction, where opponents suppress each other and separate spatially, and attractive interaction, where components reinforce one another and the resource aggregates.
This talk presents a complete qualitative theory of the attractive case in a mean-field setting, where each position interacts with the averaged presence of the system over all remaining positions. The model is a single nonlinear map of the simplex into itself, parameterized by time-invariant constants describing each position's favorability.
Under identical conditions, every trajectory converges to the barycenter: attractive interaction acts as a nonlinear consensus protocol erasing all initial advantages, though convergence slows down quadratically in the number of positions, so large systems linger in transient non-uniform states. Under heterogeneous conditions, the equilibrium is explicit in arbitrary dimension: each share is either zero or one minus the ratio of a harmonic-type threshold to the corresponding constant. This yields an exact threshold criterion separating coexistence from competitive exclusion, with neither oscillations nor chaos — the asymptotics is always a single stable fixed point. Transitions between regimes occur through transcritical bifurcations with explicit thresholds, which yield criteria for steering the system toward a prescribed equilibrium. Conservation of the resource forbids complete extinction; the maximal collapse is total aggregation at one position.
As an outlook, a numerical example with history-dependent favorability constants induced by delayed feedback suggests that the fixed-point regime is not robust: periodic and quasi-periodic redistribution of the resource is observed, though a rigorous analysis of this high-dimensional setting remains open.

Lara Theallier

(Humboldt-Universität zu Berlin)
Convergence of Crouzeix-Raviart FEM for Ginzburg-Landau type semilinearities

The Landau-de Gennes model for nematic liquid crystals provides
computational challenges within a non-convex minimization problem with topological singularities called vortices.
The energy landscape in this non-convex Ginzburg-Landau type minimisation problem is unexpectedly rich with many stationary points of the energy functional and severe difficulties for local solve. Non-conforming Crouzeix-Raviart finite elements allow for lower energy bounds in the asymptotic range of sufficiently fine meshes and immediate approximation of inhomogeneous Dirichlet data.
The presentation discusses a priori estimates and general convergence results for the Crouzeix-Raviart FEM.

Oleksandra Vinnichenko

(National Academy of Sciences of Ukraine)
Symmetry analysis of differential equations. Nyzhnyk models

This talk is devoted to symmetry analysis, one of the most powerful and versatile tools in the study of nonlinear differential equations. Symmetry methods provide numerous advantages, including the reduction of differential equations to simpler forms, the construction of exact solutions and conservation laws, the identification of hidden geometric and algebraic structures.
The presentation will begin with an accessible introduction to the basic concepts of Lie symmetries. Using a simple differential equation as an example, we will demonstrate the complete process of computing infinitesimal generators and applying symmetry methods. This introductory example will naturally lead to more advanced applications, illustrating the effectiveness of symmetry analysis in modern mathematical physics, with a particular focus on the Nyzhnyk models.
Originating from the work of Leonid Nyzhnyk in 1980 within the framework of the inverse scattering method, these $(1+2)$-dimensional systems describe a variety of nonlinear phenomena depending on their dispersive and symmetry properties. The core of the presentation will be devoted to the symmetry analysis of the dispersionless symmetric potential Nyzhnyk equation. We will present its maximal Lie invariance pseudoalgebra and the corresponding point-symmetry pseudogroups, computed using an original version of the algebraic megaideals-based method. Furthermore, we will demonstrate how Lie reductions of this equation lead to the construction of wide families of new exact solutions in closed form. Finally, we will briefly discuss the extension of this analysis to hidden symmetries and conservation laws, highlighting the rich geometric structure underlying these nonlinear models.

Yu Wang

(Potsdam Institute for Climate Impact Research)

Relative phase-locking in adaptively delay-coupled oscillators

Joint work with Serhiy Yanchuk (School of Mathematical Sciences, University College Cork, Cork T12 XF62, Ireland; Potsdam Institute for Climate Impact Research, 14473 Potsdam, Germany), Jan Sieber (Department of Mathematics and Statistics, University of Exeter, Exeter EX4 4QF, U.K.), and Juergen Kurths (Potsdam Institute for Climate Impact Research, 14473 Potsdam, Germany; Department of Physics, Humboldt-Universität zu Berlin, 10099 Berlin, Germany)

We study phase locking in two adaptively coupled phase oscillators that include delayed interactions and asymmetric slow adaptation, see Fig. 1. The system exhibits phase-locked relative periodic solutions characterized by alternating slow drifts and fast winding transitions. Based on critical manifold analysis, we identify that phase-locked relative periodic trajectories drift along stable manifold sheets until they reach saddle-node boundaries, where they undergo fast winding transitions and are finally captured by another stable sheet. The number of winding jumps over one slow period classifies the resulting locking states. We show that such phase-locked periodic solutions are not isolated and appear in finite regions. By extending DDE-BIFTOOL routines to account for phase-shift symmetry, our results further show that these solutions persist as stable families. In addition, we discuss the multistability of the relative phase-locked states and reveal that different initial histories lead to the coexistence of distinct phase-locked periodic solutions.

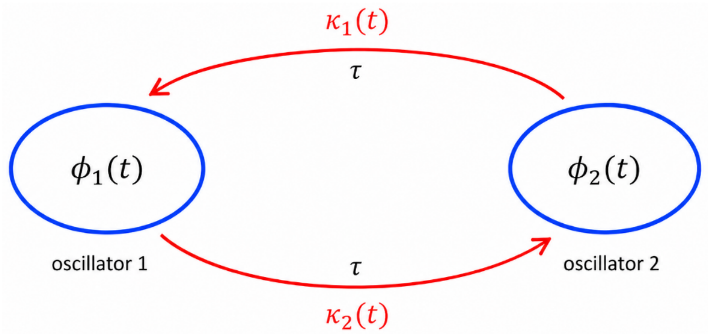

Figure 1. Two adaptively coupled phase oscillators with time delay.

Barbara Zwicknagl

(Humboldt-Universität zu Berlin)

Formation of microstructures in materials and singularly perturbed multiwell problems

We discuss recent results on variational models for pattern formation in certain materials, including helimagnetic compounds and shape-memory alloys. Precisely, we consider functionals that contain a non-convex multi-well bulk energy favouring finitely many gradients, and a singular perturbation in terms of the total variation of the second derivative. Relations to discrete models from statistical mechanics are studied, and the scaling laws for the infima of the energies in the case of incompatible boundary conditions are derived. Extensions to the vectorial case and the occurrence of topological singularities are briefly discussed.
This talk is based on joint works with J. Ginster, M. Koser, A. Rüland, and A. Tribuzio.