1st GAMM Activity Group Workshop

“Analysis of Partial Differential Equations and Calculus of Variations”

September 22–24, 2025
Faculty of Mathematics, TU Dresden

Stefan Neukamm, September 20, 2025

Scientific Scope

Since over a decade, the GAMM Activity Group on Analysis of Partial Differential Equations and Calculus of Variations (and its predecessor founded in 2013) has provided a platform for exchanging recent advances in the analysis of PDEs, the Calculus of Variations, and their role in the formulation of mathematical models in the sciences. The annual workshop brings together leading experts and early-career researchers to discuss current challenges and emerging developments in the field.

Invited Speakers

- Li Chen (University of Mannheim)
- Manuel Friedrich (FAU Erlangen-Nürnberg)
- Gero Friesecke (Technical University of Munich)
- Antoine Gloria (LJLL Sorbonne Université)
- Anna Marciniak-Czochra (Heidelberg University)
- Daniel Matthes (Technical University of Munich)
- Mathias Schäffner (Martin Luther University Halle-Wittenberg)
- Marita Thomas (FU Berlin)
- Maria G. Westdickenberg (RWTH Aachen University)

Program

Monday, September 22, 2025

Time	Speaker	Title
13:00 - 14:00	Registration	
14:00 - 14:40	**Marita Thomas**	Plastic limit of a viscoplastic Burgers equation
14:40 - 15:00	Patrik Knopf	Nonlocal-to-local convergence of convolution operators with singular, possibly anisotropic kernels
15:00 - 15:20	Guy Foghem	Robust log-convex interpolation inequalities fractional Sobolev seminorms via Chebyshev-type inequalities
15:20 - 16:00	Coffee break	
16:00 - 16:40	**Maria G. Westdickenberg**	Convergence behavior of the Mullins–Sekerka dynamics in the full-space: stories in two and three dimensions
16:40 - 17:00	Luisa Plato	A relative energy inequality for an anisotropic Navier–Stokes–Nernst–Planck–Poisson system — Weak-strong uniqueness and *a posteriori* error estimates

17:00 - 17:20	Christopher Körber	Linearization for fluid structure interaction
17:20 - 17:40	Malte Kampschulte	Variational limits for problems with inertia

Tuesday, September 23, 2025

Time	Speaker	Title
09:00 - 09:40	**Gero Friesecke**	Mass splitting in the generalized Euler equations: a new explanation via discretization
09:40 - 10:00	Juliane Krautz	The dynamic Schrödinger problem on metric graphs
10:00 - 10:20	Martin Jesenko	Γ-convergence of a discrete Kirchhoff rod energy
10:20 - 11:00	Coffee break	
11:00 - 11:40	**Manuel Friedrich**	Dimension reduction for elastic materials with voids
11:40 - 12:00	Kai Richter	Commutativity of dimension reduction and vanishing viscosity for thin nonlinear elastoplastic rods in the bending regime
12:00 - 12:20	Lennart Machill	The energy scaling behaviour for singular perturbation problems of staircase type in linearized elasticity
12:20 - 14:00	Lunch	
14:00 - 14:40	**Antoine Gloria**	Anderson localization and the landscape function
14:40 - 15:00	Jonas Ingmanns	Quantitative homogenization of geometric motions through a random field of obstacles in arbitrary dimensions
15:00 - 15:20	Lucas Broux	A geometric view upon the renormalisation of the Φ^4 equation
15:20 - 16:00	Coffee break	
16:00 - 16:40	**Mathias Schäffner**	Regularity for monotone operators and applications to homogenization
16:40 - 17:00	David Wiedemann	Polarization filter as a homogenisation limit for Maxwell's equations
17:15 - 18:15	*Meeting of the activity group*[1]	
19:00	Conference dinner	

[1] Location: Room 250, building Z21 (Zellescher Weg 21-25a), see `https://navigator.tu-dresden.de/etplan/z21/02/raum/342102.0850`

Wednesday, September 24, 2025

Time	Speaker	Title
09:00 - 09:40	**Daniel Matthes**	Corvariance modulated optimal transport: geometry and gradient flows
09:40 - 10:20	**Li Chen**	On the mean-field limit of Vlasov–Poisson–Fokker–Planck equations
10:20 - 10:40	Lukas Bol	Two-dimensional signal-dependent parabolic-elliptic Keller–Segel system and its means field derivation
10:40 - 11:20	Coffee break	
11:20 - 11:40	Artur Stephan	Derivation of the fourth order DLSS equation with nonlinear mobility via chemical reactions
11:40 - 12:00	Julian Blawid	Stress-Modulated Growth of Hyperelastic Materials in the Presence of Nutrients
12:00 - 12:40	**Anna Marciniak-Czochra**	How Mechanics Shapes Morphogenesis: A PDE Framework for Emergent Patterns

Venue

All presentations and coffee breaks will take place in lecture hall **WIL A317**[2] in the Willers-Bau[3], which is located on the main campus of Technische Universität Dresden, close to Fritz-Förster-Platz. The building can be reached conveniently by public transport: the nearest bus stop is *Technische Universität (Fr.-Foerster-Platz), Dresden* (lines 61, 66). The tram stop *Reichenbachstraße* (lines 3, 8) is a 5-minute walk away. The trans station *Dresden Hauptbahnhof* is a 10-minute walk away.


Entrance of Willers-Bau at car park east

Note: Parts of the Willers-Bau are currently under construction. We therefore recommend using the entrance at the car park `https://maps.app.goo.gl/KpjFjcvsgd4PxAmn7`. Enter through the door beneath the sundial. Inside the building, lecture hall A317 is located on the third floor of Wing A (the wing closest to the car park).

Conference Dinner

The conference dinner will take place on **Tuesday, September 23, 2025** starting at **19:00** at **Lohrmann's Brew Restaurant**. The dinner is open only to participants who have registered in advance. Dinner and water are provided free of charge; additional drinks must be paid by

[2]For orientation, please consult the TU Dresden Campus Navigator: `http://navigator.tu-dresden.de/etplan/wil/02/raum/219202.0580`

[3]Technische Universität Dresden, Zellescher Weg 12–14, 01069 Dresden, Germany

the guests. For directions, please consult the restaurant on Google Maps: `https://maps.app.goo.gl/WVN5WHtGydbNRaar6`.

Lunch Places

- Alte Mensa (9-minute walk)
- Mensa Siedepunkt (5-minute walk)
- Mensa Zeltschlösschen (5-minute walk)
- Mensa WUeins (15-minute walk)
- Aydin Aydin Firat Kebap-Haus (5-minute walk)
- Café Bianco (5-minute walk)

Abstracts

Plastic limit of a viscoplastic Burgers equation

Marita Thomas, FU Berlin

We study the Burgers equation featuring an additional term governed by a positively 1-homogeneous potential. This problem is motivated by the so-called Hibler's sea ice model. It treats sea ice as a non-Newtonian fluid, where the stress tensor includes such a term in order to account for the plastic response of the ice. For this simplified one-dimensional model we introduce a suitable notion of solution in the framework of BV-solutions. Starting in the regularized setting of a viscoplastic Burgers equation, we study the existence of such generalized solutions. We investigate the passage to the plastic limit and further discuss the properties of the solutions. This is joint work in progress with Edriss Titi (U Cambridge) and Xin Liu (Texas A & M), supported by the DFG within project C09 of CRC 1114.

Nonlocal-to-local convergence of convolution operators with singular, possibly anisotropic kernels

Patrik Knopf, Unviersität Regensburg

The goal of *nonlocal-to-local* convergence is to show that certain singular, nonlocal convolution-type integral operators converge to a local differential operator as the convolution kernel concentrates at zero. This can be a useful tool in the physical justification of mathematical models (e.g., the Cahn–Hilliard equation), especially when a desired local differential operator can not be derived by microscopic laws.

The nonlocal-to-local convergence of convolution operators with radially symmetric (i.e., isotropic) kernels having $W^{1,1}$-regularity is already very well understood. However, the assumption of $W^{1,1}$-regularity is too strong for many applications. Also, in some situations (e.g., crystallization phenomena), convolution kernels are not radially symmetric but merely even (i.e., anisotropic).

In an ongoing collaboration (joint work with Helmut Abels and Christoph Hurm), we intend to establish strong nonlocal-to-local convergence results with convergence rates for anisotropic kernels satisfying lower regularity assumptions. These results can, for example, be applied to nonlocal phase-field models such as the anisotropic Cahn–Hilliard equation.

Robust log-convex interpolation inequalities fractional Sobolev seminorms via Chebyshev-type inequalities.

Guy Foghem, BTU Cottbus-Senftenberg

We investigate several Chebyshev-type inequalities for general, non-monotone functions. These inequalities play a central role in deriving robust log-convex interpolation inequalities within the scale of (fractional) Sobolev seminorms. As applications of these results, we explore topics such as asymptotic compactness, convergence of Sobolev traces, and the passage from nonlocal to local behavior for weak solutions of the boundary Dirichlet problem associated with the regional fractional p-Laplacian $(-\Delta)^s_{p,\Omega}$, with $s \in (0, 1]$ and $p \in (1, \infty)$, on smooth a domain $\Omega \subset \mathbb{R}^d$.

Convergence behavior of the Mullins-Sekerka dynamics in the full-space: stories in two and three dimensions

Maria G. Westdickenberg, RWTH Aachen University

We study optimal decay rates for the Mullins-Sekerka evolution, a nonlocal, parabolic free boundary problem from materials science. Our main result establishes convergence of BV solutions to the planar profile in the physically relevant case of ambient space dimension three. Far from assuming small or well-prepared initial data, we allow for initial configurations that do not have graph structure and in which the region of positive phase is not simply connected, hence explicitly including the regime of Ostwald ripening. This is joint work with Felix Otto (MPI Leipzig) and Richard Schubert (University of Bonn). The situation in ambient space dimension two is more complicated, and we comment on work in progress with Wenhui Shi and Michael Westdickenberg (both at RWTH Aachen University) and complementary work in progress with Otto, Schubert, and Elena Salguero (MPI Leipzig).

A relative energy inequality for an anisotropic Navier–Stokes–Nernst–Planck–Poisson system — Weak-strong uniqueness and *a posteriori* error estimates

Luisa Plato, WIAS Berlin

In this talk, I will present results from [1], joint work with Robert Lasarzik, building on the existence of suitable weak solutions to the anisotropic Navier–Stokes–Nernst–Planck–Poisson (NSNPP) system established in [2]. We derive a relative energy inequality for these solutions, which provides the foundation for proving weak-strong uniqueness. Furthermore, the relative energy framework allows us to obtain rigorous a posteriori error estimates. Our analysis focuses on the high-viscosity, low-Reynolds-number limit of the NSNPP system, which reduces to the anisotropic Stokes–Nernst–Planck–Poisson (SNPP) model. In this regime, we establish error bounds in natural energy and dissipation norms that quantify the distance between solutions to the NSNPP and SNPP systems.

[1] R. Lasarzik and L. Plato, *A relative energy inequality for an anisotropic Navier–Stokes–Nernst–Planck–Poisson system — Weak-strong uniqueness and a posteriori error estimates*, preprint, 2025. `https://www.wias-berlin.de/preprint/3208/wias_preprints_3208.pdf`

[2] D. Hömberg, R. Lasarzik and L. Plato, *Existence of suitable weak solutions to an anisotropic electrokinetic flow model*, Journal of Differential Equations, 2024. `https://www.sciencedirect.com/science/article/abs/pii/S0022039625001305`

Linearization for Fluid Structure Interaction

Christopher Körber, Charles University Prague

We consider an elastic body immersed into an incompressible viscous fluid, contained in a bounded lipschitz domain of dimension bigger or equal to two. The solid is partly attached to the boundary of the fluid domain. The fluid is modeled by the incompressible Navier-Stokes equations in Eulerian coordinates, while the solid is described by its deformation in Lagrangian coordinates. The existence of weak solutions for this problem was established in [1]. Now we assume smallness of external forces, meaning the force is given by $f_\delta = \delta f$ for some positive scaling parameter $\delta > 0$. We linearize the deformation describing the solid around the identity and the fluid velocity around zero. We prove that, assuming a suitable scaling of the initial conditions, the resulting first order perturbations converge weakly towards the unique weak solution of a corresponding linearized fluid-solid interaction problem with external force f as $\delta \to 0$. Our result rigorously shows that, assuming smallness of external forces and initial conditions, fluid-structure interaction systems involving nonlinear elasticity can be approximated by corresponding much simpler, linearized systems.

[1] B. Benešová, M. Kampschulte and S. Schwarzacher, *A variational approach to hyperbolic evolutions and fluid-structure interactions*, Journal of the European Mathematical Society (JEMS), 2024. https://doi.org/10.4171/JEMS/1353

Variational limits for problems with inertia

Malte Kampschulte, Charles University Prague

The solution to a static problem can be seen in two ways, as the minimizer of an energy functional or the solution to the corresponding Euler-Lagrange equation. Similarly, for quasistatic problems, one can define curves of maximal slope in terms of energy or deal with the corresponding equation. Recent results have allowed us to understand inertial problems in a related variational way.

Given a family of such problems, one can then ask about the limit problem, either in the straightforward way using the equation or, more interestingly, in terms of the energy. In the static case the latter is done using Γ-convergence which for the quasistatic case naturally evolves to EDP-convergence and related concepts. The question is now, can we also use similar concepts when there is inertia involved as well?

The aim of this talk is to give a partial positive answer for the example of the limiting process from nonlinear to linearized viscoelastodynamics for a general frame-indifferent model of Kelvin-Voigt rheology. This is based on joint work with Barbora Benešová and Martin Kružík.

Mass splitting in the generalized Euler equations: a new explanation via discretization

Gero Friesecke, Technical University of Munich

Arnold made the celebrated observation that solutions to the incompressible Euler equations of fluid dynamics correspond to geodesics in the group of volume-preserving diffeomorphisms. A nontrivial fact is that minimizers of the corresponding variational principle may not exist. Brenier introduced a relaxation which he showed to be well-posed. Physically this formulation

allows mass splitting, i.e., a fluid particle can move from A to B via an ensemble of trajectories. Mathematically this formulation is an instance of multi-marginal optimal transport; for a simple introduction to this formulation see my recent textbook on optimal transport [1]. After revieving the different formulations of the Euler equations, we
- show that mass splitting still occurs after discretizing Brenier's relaxation in space and time
- provide a short, transparent argument for the mass splitting which is much simpler than previous analyses of the continuous case.

We close with a brief discussion from a modeling point of view: what is physically more correct, Euler (no mass splitting) or Brenier (mass splitting)?

[1] G. Friesecke, *Optimal Transport: a Comprehensive Introduction to Modeling, Analysis, Simulation, Applications*, SIAM, 2025, `https://epubs.siam.org/doi/book/10.1137/1.9781611978094`

The dynamic Schrödinger problem on metric graphs

Juliane Krautz, Universität Augsburg

We study the dynamic formulation of the Schrödinger Problem on metric graphs. Using the Direct Method of Calculus of Variations, we show the existence of minimizers and investigate the connection to dynamic Optimal Transport. A particular focus lies on the study of Γ-convergence between both problems for vanishing diffusive effects.

Γ-convergence of a discrete Kirchhoff rod energy

Martin Jesenko, Univerza v Ljubljani

This presentation is based on [1]. The work is motivated by the classical discrete elastic rod model [2] by Bergou *et al.* We derive a discrete version of the Kirchhoff elastic energy for rods undergoing bending and torsion and prove Γ-convergence to the continuous model. This discrete energy is given by the bending and torsion energy of an interpolating conforming polynomial curve and provides a simple formula for the bending energy depending on each discrete segment only on angle and adjacent edge lengths. For the $\liminf$-inequality, we need to introduce penalty terms to ensure arc-length parametrization in the limit. For the recovery sequence, a discretization with equal Euclidean distance between consecutive points is constructed. Particular care is taken to treat the interaction between bending and torsion by employing a discrete version of the Bishop frame.

[1] P. Dondl; C. A. Hounkpe; M. Jesenko. *Γ-convergence of a discrete Kirchhoff rod energy.*, ESAIM Control Optim. Calc. Var. 30 (2024), Paper No. 53, 31 pp. `https://doi.org/10.1051/cocv/2024043`

[2] M. Bergou *et al. Discrete elastic rods.* ACM SIGGRAPH 2008 papers. ACM, 2008, pp. 1–12. `https://doi.org/10.1145/1399504.1360662`

Dimension reduction for elastic materials with voids

Manuel Friedrich, FAU Erlangen-Nürnberg

In this talk I present some recent dimension-reduction results for elastic materials with voids. We consider three-dimensional models with an elastic bulk and an interfacial energy featuring a Willmore-type curvature penalization. By Gamma-convergence we rigorously derive lower-dimensional models for rods and plates where the effective limit comprises a classical elastic bending energy and surface terms reflecting the possibility that voids can persist in the limit and that the material can be folded or broken apart into several pieces. The main ingredient for the analysis is a novel rigidity estimate in varying domains under vanishing curvature regularization.

Commutativity of dimension reduction and vanishing viscosity for thin nonlinear elastoplastic rods in the bending regime

Kai Richter, TU Dresden

In this talk, we discuss a generalized gradient system, describing the nonlinear elastoplastic behavior of a thin rod-shaped body. As solutions to this system are expected to admit jumps, a modern approach is to regularize the system by introducing small viscous terms and passing to the limit in a suitable way. This approach is known as the vanishing viscosity approach. This results in two small parameters, one for the viscosity and one for the thickness of the rod, for which we study the limit as the parameters tend to 0. We study the commutativity of these two limits rigorously in the energy regime of bending deformations. The bending regime leads to additional difficulties in the construction of recovery sequences for the local slope, as common approaches in similar works utilize dealing with infinitesimal deformations in the limit. This is joint work with Stefan Neukamm, supported by the DFG Research Unit FOR 3013 Vector- and Tensor-Valued Surface PDEs.

The energy scaling behaviour for singular perturbation problems of staircase type in linearized elasticity

Lennart Machill, University of Bonn

In the talk, we discuss scaling laws for singular perturbation problems of "staircase type" within the geometrically linearized theory of elasticity. More precisely, we focus on a three-well problem and show that the scaling depends both on the lamination order of the prescribed Dirichlet boundary data and on the number of (non-)degenerate symmetrized rank-one directions in the symmetrized lamination convex hull. Our analysis is based on localization techniques in Fourier space. This is joint work with Angkana Rüland.

Anderson localization and the landscape function

Antoine Gloria, LJLL Sorbonne Université

In this talk I will consider the Schrödinger equation in a random potential. I will first recall what is known on the spectral-theoretical side, and describe Anderson localization. Then I will discuss the landscape function, recently introduced by Filoche and Mayboroda, and illustrate in which sense it predicts the supports of localized eigenstates. I shall then construct this function on the whole space, and conclude with some open problems. This is based on joint works with Guy David (Orsay) and Svitlana Mayboroda (ETH and IAS), and with Felipe Hernandez (Penn State).

Quantitative homogenization of geometric motions through a random field of obstacles in arbitrary dimensions

Jonas Ingmanns, Institute of Science and Technology Austria

Consider the evolution of sets by forced mean curvature flow through a field of random obstacles. The effective large scale behaviour is expected to be a first order motion. However, previous results heavily relied on the assumption that there is a global minimum speed of expansion and hence on the absence of any actual obstacles.

We obtain a quantitative homogenization result even with actual obstacles, potentially allowing the interface to get stuck locally, eventually leading to enclosures behind a main front. So far in this regime not even a qualitative stochastic homogenization result had been available. The existence of a global minimum speed is replaced with a probabilistic assumption. We assume that on large scales with high probability 'fat' sets can be approximated from within by sets which are increasing with respect to the evolution and expand at an 'effective' minimum speed - that is, we ignore smaller holes left behind. This assumption is satisfied for example if the obstacles are distributed according to a Poisson point process with low enough intensity.

The talk is based on joint work with Julian Fischer (Institute of Science and Technology Austria).

A geometric view upon the renormalisation of the Φ^4 equation

Lucas Broux, Max Planck Institute for Mathematics in the Sciences

This talk will be concerned with the Φ^4 equation, which is a nonlinear partial differential equation perturbed by an additive random (and rough) noise. We are interested in the range of noises where this stochastic PDE is singular (i.e. is classically ill-posed) but subcritical (i.e. the nonlinearity formally vanishes at small scales). In this range, even giving a meaning to the equation is highly non-trivial and relies on an appropriate procedure of regularisation and renormalisation. I will be describing how taking a geometric viewpoint upon the solution manifold gives rise to a new perspective on what in the theory of regularity structures is called a "model" for the equation. If time permits, I will also briefly present a recently-developed "intrinsic" approach for a solution theory, yielding well-posedness of the equation given this model as input. (Based on joint works with Felix Otto, Rhys Steele and Markus Tempelmayr)

[1] L. Broux, F. Otto, M. Tempelmayr, *Lecture notes on Malliavin calculus in regularity structures*, Arxiv preprint, 2024. `https://doi.org/10.48550/arXiv.2503.01621`

[2] L. Broux, F. Otto, R. Steele, *Multi-index Based Solution Theory to the Φ^4 Equation in the Full Subcritical Regime*, Arxiv preprint, 2025. `https://doi.org/10.48550/arXiv.2503.01621`

Regularity for monotone operators and applications to homogenization

Mathias Schäffner, MLU Halle-Wittenberg

I will present some regularity results for solutions of nonlinear elliptic equations. Assuming only mild monotonicity and growth conditions on the operator, we establish higher integrability for the gradient of solutions. The main motivation for this is that these monotonicity and growth conditions are stable under homogenization. As an application, we obtain uniform Calderon-Zygmund and Lipschitz estimates (on large scales) for p Laplacian type operators with rapidly oscillating periodic coefficients. This is based on joint work with Lukas Koch. If time permits, I will also discuss work in progress (together with Nicolas Clozeau & Antoine Gloria) on related results in the case of random coefficients.

Interface conditions for Maxwell's equations by homogenization of thin inclusions: transmission, reflection or polarization

David Wiedemann, TU Dortmund

We consider the time-harmonic Maxwell equations in complex geometries that model polarization filters or Faraday cages. We study the situation that the domain of interest contains inclusions with infinite conductivity that are distributed in a periodic fashion along a surface. The periodicity is η and the shape of the inclusion depends also on η since we want to model thin structures. Depending on geometric properties of the inclusions, the effective limit system for $\eta \to 0$ can imply perfect transmission, perfect reflection or polarization [1].

[1] B. Schweizer, D. Wiedemann, *Interface conditions for Maxwell's equations by homogenization of thin inclusions: transmission, reflection or polarization*, arXiv:2501.17713, 2025. `https://arxiv.org/abs/2501.17713`

[2] B. Delourme, B. Schweizer, D. Wiedemann, *On polarization interface conditions for time-harmonic Maxwell's equations*, arXiv:2507.19192, 2025. `https://arxiv.org/abs/2507.19192`

Corvariance modulated optimal transport: geometry and gradient flows

Daniel Matthes, Technical University of Munich

This is about a variant of optimal mass transport in which the mobility has a time-dependent global anisotropy. Specifically, it is less costly to move in directions in which the mass distribution is already spread out, and more costly to explore alternative directions. The induced metric on the space of probability measures is perfectly adapted to study the rate of convergence in preconditioned MCMC sampling algorithms: in the mean field limit, the particle density approaches its terminal Gaussian distribution at an exponential rate that is independent of the Gaussian's covariance.

I shall present several analytic results about the metric. The first is on splitting: the new metric is the sum of two simpler metrics, one measuring the distance in terms of first and second moments, the other one measuring in terms of shapes. The second result is about geodesic convexity and the related rates of convergence in gradient flows, like sampling algorithms. The third and only partial result is about geodesics, that we prove to exist for sufficiently close densities, or densities with multiple reflection symmetries. We also characterize geodesics in terms of particle trajectories, that are no longer straight line as in the genuine Wasserstein metric, but follow more complicated curves that satisfy second order ordinary differential equations.

This is joint work with Andre Schlichting, Matthias Erbar, Franca Hoffmann and Martin Burger.

On the mean-field limit of Vlasov–Poisson–Fokker–Planck equations

Li Chen, University of Mannheim

In this talk I will focus on the derivation of effective descriptions for interacting many-body systems, which is an important branch of applied mathematics. We prove a propagation of chaos result for a system of N particles subject to Newtonian time evolution with or without additional white noise influencing the velocities of the particles. We assume that the particles interact according to a regularized Coulomb-interaction with a regularization parameter that vanishes in the $N \to \infty$ limit. The respective effective description is the so called Vlasov-Poisson-Fokker-Planck (VPFP), respectively the Vlasov-Poisson (VP) equation in the case of no or sub-dominant white noise. To obtain our result we combine the relative entropy method from Jabin and Wang (2016) with the control on the difference between the trajectories of the true and the effective description provided in Huang, Liu, and Pickl (2020) for the VPFP case respectively in Lazarovic and Pickl for the VP case. This allows us to prove strong L^1 convergence of the marginals. This talk is based on the joint work with Jinwook Jung, Peter Pickl, and Zhenfu Wang.

Two-dimensional signal-dependent parabolic-elliptic Keller-Segel system and its means field derivation

Lukas Bol, University of Mannheim

In this paper, the well-posedness of two-dimensional signal-dependent Keller-Segel system and its mean field derivation from a interacting particle system on the whole space are investigated. The signal dependence effect is reflected by the fact that the diffusion coefficient in the particle system depends nonlinearly on the interactions between the individuals. Therefore, the mathematical challenge in studying the well-posedness of this system lies in the possible degeneracy and the aggregation effect when the concentration of signal becomes unbounded. The well-established method on bounded domain, to obtain the appropriate estimates for the signal concentration, is invalid for the whole space case. Motivated by the entropy minimization method and Onofri's inequality, which has been successfully applied for parabolic-parabolic Keller-Segel system, we establish a complete entropy estimate benefited from linear diffusion term, which plays important role in obtaining the L^p estimates for the solution. Furthermore, the upper bound for the concentration of signal is obtained. Based on estimates we obtained for the density of cells, the rigorous mean-field derivation is proved by introducing an intermediate particle system with a mollified interaction potential with logarithmic scaling. By using this mollification, we obtain the convergence of the particle trajectories in expectation, which implies the weak propagation of chaos. Additionally, under a regularity assumption of the initial data, we infer higher regularity for the solutions, which allows us to use relative entropy method to derive the strong L^1 convergence for the propagation of chaos.

[1] Lukas Bol, Li Chen, Yue Li, *Two-dimensional signal-dependent parabolic-elliptic Keller-Segel system and its mean-field derivation*, Journal of Differential Equations, Volume 450, 2026. `https://doi.org/10.1016/j.jde.2025.113712`

Derivation of the fourth order DLSS equation with nonlinear mobility via chemical reactions

Artur Stephan, Technische Universität Wien

We provide a derivation of the fourth-order DLSS equation based on an interpretation as a chemical reaction network. We consider on the discretized circle the rate equation for the process where pairs of particles sitting on the same site jump simultaneously to the two neighboring sites, and the reverse jump where a pair of particles sitting on a common site jump simultaneously to the site in the middle. Depending on the reaction rates, in the vanishing mesh size limit we obtain either the classical DLSS equation or a variant with nonlinear mobility of power type. We identify the limiting gradient structure to be driven by entropy with respect to a generalization of diffusive transport with nonlinear mobility via evolutionary convergence for gradient systems. Furthermore, the DLSS equation with nonlinear mobility of the power type shares qualitative similarities with the fast diffusion and porous medium equations, since we find traveling wave solutions with algebraic tails and polynomial compact support, respectively.

The talk is based on joint work with Alexander Mielke (Berlin) and André Schlichting (Ulm).

Morphoelastic Growth at Large Strains

Julian Blawid, University of Regensburg

We discuss a model for morphoelastic growth of second gradient viscoelastic materials. Morphoelastic growth refers to the growth of tissue under the influence of elastic stress. Our model features a multiplicative decomposition of the deformation gradient into a part related to growth and an elastic contribution. While the volumetric change due to growth of the tissue is determined by an ordinary differential equation on a Banach space, the total deformation solves a quasistatic momentum balance equation.

How Mechanics Shapes Morphogenesis: A PDE Framework for Emergent Patterns

Anna Marciniak-Czochra, Heidelberg University

In this talk, I introduce a new mechanochemical framework for morphogenesis in regenerating epithelia, motivated by recent experimental findings and designed to provide mechanistic insight into how physical forces and biochemical signals interact to control pattern formation in living tissues. Using Hydra morphogenesis as a case study, the PDE system couples morphogen dynamics with tissue mechanics through a positive feedback loop: mechanical stretching enhances morphogen production, while morphogen concentration regulates tissue elasticity. Bifurcation and stability analysis reveal how symmetry breaking and single-peaked patterns emerge. We compare this framework with existing mechanisms such as curvature–morphogen coupling and classical Turing-type diffusion-driven instability, demonstrating how mechanical feedback offers an alternative route to long-range inhibition. Theoretical predictions are consistent with experimental observations.

Support

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Organizers

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