ALEX 2018

Analysis of Evolutionary and Complex Systems

Workshop in Honor of Alexander Mielke's Sixtieth Birthday

Weierstrass Institute for
Applied Analysis and Stochastics
September 24 – 28, 2018

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ALEX 2018

AnaLysis of Evolutionary and compleX systems

September 24 – 28, 2018

Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
Berlin, Germany

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Welcome to the workshop “ALEX 2018 – AnaLysis of Evolutionary and compleX systems” at the Weierstrass Institute Berlin. The workshop addresses new aspects for evolutionary PDEs with a wide range of applications in physics, biology, chemistry, and engineering. The focus will be put on four main topics:

- Variational methods for continuum mechanics,
- Gradient and Hamiltonian structures,
- Dynamical systems,
- Multiscale problems.

Applications may include modeling of smart materials, interrelation between stochastics and PDEs, multi-particle systems, transition from discrete to continuum, quantum mechanics, and reaction-diffusion systems.

This booklet contains the workshop program, the abstracts of all talks, as well as general information. Assistance in the case of questions will be given by anybody of the WIAS staff participating in the workshop (**wearing blue badges**). Please further note that **smoking is not allowed** in the building.

You can connect to the internet via the **eduroam** network, where the login credentials are provided by your home institution. If your institution does not participate in the eduroam service, you can obtain a **user account** from the reception desk.

Entrance to the building will be provided by showing your participant’s badge. Please wear it. Sorry, but the receptionist is supposed to not let you in without it.

We wish you a stimulating and enjoyable experience at ALEX 2018!

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Monday, 09/24/2018	
08:00 - 09:15	REGISTRATION
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10:15	**Sören Bartels (Albert-Ludwigs-Universität Freiburg)** Approximating evolutions of self-avoiding inextensible curves and elastic knots
10:45 - 11:15	COFFEE BREAK
11:15	**Martin Heida (Weierstraß-Institut Berlin)** On convergences of the squareroot approximation scheme to the Fokker–Planck operator
11:45	**Ralf Kornhuber (Freie Universität Berlin)** Fractals, homogenization, and multigrid
12:15	**Stefan Neukamm (Technische Universität Dresden)** Quantitative homogenization in nonlinear elasticity
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14:15	**Felix Otto (Max Planck Institute for Mathematics in the Sciences, Leipzig)** Multipole expansion in random media
15:00	**Jan Maas (Institute of Science and Technology Austria)** Gromov–Hausdorff convergence of discrete optimal transport
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16:00	**Julian Fischer (Institute of Science and Technology Austria)** Evolution problems for interfaces: Solution concepts and their uniqueness properties
16:30	**Jürgen Sprekels (Weierstraß-Institut Berlin)** Well-posedness, regularity and optimal control of general Cahn–Hilliard systems with fractional operators
17:00	**Alain Miranville (Université de Poitiers)** Cahn–Hilliard models with logarithmic nonlinear terms

Tuesday, 09/25/2018	
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10:15	**Tomaš Roubíček (Charles University, Prague)** Dynamical problems in continuum mechanics of solids at large strains
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11:45	**Carolin Kreisbeck (Universiteit Utrecht)** Relaxation of nonlocal supremal functionals
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14:15	**Yann Brenier (CNRS, Paris)** From initial value problems to some generalized mean field games by convex minimization
15:00	**Barbara Niethammer (Universität Bonn)** Mass transport in Fokker–Planck equations with tilted periodic potential
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16:00	**Sergio Conti (Universität Bonn)** Stress-space relaxation
16:30	**Georg Dolzmann (Universität Regensburg)** Variational modelling of crystal plasticity - analytical and numerical challenges
17:00	**Martin Brokate (Technische Universität München)** Differential sensitivity in rate independent evolutions

Lectures on Wednesday take place at **Humboldt-Universität zu Berlin**, Dorotheenstraße 24, lecture room 1.101 in the form of an open colloquium. Please find more information, including details on the social event and the workshop dinner, on page 52.

Wednesday, 09/26/2018	
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16:15	**Dorothee Knees (Universität Kassel)** Rate-independent systems in the context of damage and fracture
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10:15	**Elisabetta Rocca (Università degli studi di Pavia)** Recent advances in diffuse interface tumor growth analysis
10:45 - 11:15	Coffee break
11:15	**Johannes Zimmer (University of Bath)** On fluctuations in particle systems and their links to macroscopic models
11:45	**Michiel Renger (Weierstraß-Institut Berlin)** Gradient and GENERIC structures in the space of fluxes
12:15	**Markus Mittnenzweig (Weierstraß-Institut Berlin)** Hydrodynamic limit and large deviations for reaction-diffusion master equations
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16:45	**Bernold Fiedler (Freie Universität Berlin)** Oscillatory reaction networks: Far from complex-balance

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09:30	**Patrick Dondl (Albert-Ludwigs-Universität Freiburg)** The effect of forest dislocations on the evolution of a phase-field model for plastic slip
10:00	**Karoline Disser (TU Darmstadt and Weierstraß-Institut Berlin)** Global existence and stability for dissipative processes coupled across volume and surface
10:30 - 11:00	COFFEE BREAK
11:00	**Andrea Braides (Università degli Studi di Roma “Tor Vergata”)** Variational flows in heterogeneous media
11:30	**Klaus Hackl (Ruhr-Universität Bochum)** A variational approach to model reduction and homogenization in inelastic material systems
12:00	**Gianni Dal Maso (SISSA, Trieste)** Recent advances in dynamic fracture
12:45 - 13:00	CLOSING

DEPARTURE INFORMATION

Here we give some suggestions for public transport connections to Berlin’s airports. Note that all information are given in good faith, but without guarantee. Please check the homepage of Berlin’s public transport system: `https://www.bvg.de/en` Please take into account that there will be a state visit on Friday, 09/28/2018, situated on Unter den Linden, thus, the bus line TXL to Tegel airport does not operate as usual.

- **To Tegel airport:** You can either take the line U6 from U Stadtmitte to U Kurt-Schumacher-Platz (15 min) and then the bus line 128 to Tegel airport (8 min) or from U Hausvogteiplatz via the line U2 to U Ernst-Reuter-Platz (16min) and then with bus line X9 to Tegel airport (18 min).
- **To Schönefeld airport:** You can either take the line U6 from U Stadtmitte to U Tempelhof (9 min) and then by S-Bahn line S45 to Schönefeld airport (28 min) or from U Hausvogteiplatz via line U2 to Alexanderplatz (6 min) and then via regional train RB14 to Schönefeld airport (25 min). Note that Schönefeld airport lies in tariff zone C, hence, you will need a ticket for zones ABC.

Sharp interface limit for the Allen–Cahn equation with a contact angle

Helmut Abels and Maximilian Moser

University of Regensburg, Faculty of Mathematics (Germany)

We consider the sharp interface limit of the Allen-Cahn equation with homogeneous Neumann boundary conditions in a two-dimensional domain Ω, in the situation where an interface has developed and intersects $\partial\Omega$. Here a parameter $\varepsilon > 0$ in the equation, which is related to the thickness of the diffuse interface, is sent to zero. The limit problem is given by mean curvature flow with a $\pi/2$-contact angle condition and convergence using strong norms is shown for small times. Here we assume that a smooth solution to this limit problem exists on $[0, T]$ for some $T > 0$ and that it can be parametrized suitably. The strategy is as in Chen, Hilhorst, Logak [3] and Abels, Liu [1]: With asymptotic expansions we construct an approximate solution $(u_A^\varepsilon)_{\varepsilon\in(0,\varepsilon_0]}$ for the Allen-Cahn equation and estimate the difference of the exact and approximate solution with the aid of a spectral estimate for the (around $u_A^\varepsilon(.,t)$) linearized Allen-Cahn operator $-\Delta + \frac{1}{\varepsilon^2} f''(u_A^\varepsilon(.,t))$ for $t \in [0, T]$. Here the main new difficulty lies in the contact points. Therefore a suitable curvilinear coordinate system based on work of Vogel [4] is constructed. For the asymptotic expansion and the proof of the spectral estimate also ideas from Alikakos, Chen, Fusco [2] are used.

Acknowledgments: This research and the second author was financially supported by the DFG-RTG 1692 "Curvature, Cycles, and Cohomology". The support is gratefully acknowledged.

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Approximating gradient flow evolutions of self-avoiding inextensible curves and elastic knots

Sören Bartels[(1)] **and Philipp Reiter**[(2)]

(1) University of Freiburg, Department of Applied Mathematics (Germany)
(2) University of Georgia, Department of Mathematics (USA)

We discuss a semi-implicit numerical scheme that allows for minimizing the bending energy of curves within certain isotopy classes. To this end we consider a weighted sum of the bending energy B and the tangent-point functional TP, i.e.,

$$E(u) = \kappa \mathrm{B}(u) + \varrho \mathrm{TP}(u) = \frac{\kappa}{2} \int_I |u''(x)|^2 \, \mathrm{d}x + \varrho \iint_{I \times I} \frac{\mathrm{d}x \, \mathrm{d}y}{r(u(y), u(x))^q}$$

with the *tangent-point radius* $r(u(y), u(x))$ which is the radius of the circle that is tangent to the curve u at the point $u(y)$ and that intersects with u in $u(x)$.

We define evolutions via the gradient flow for E within a class of arclength parametrized curves, i.e., given an initial curve $u^0 \in H^2(I; \mathbb{R}^3)$ we look for a family $u : [0, T] \to H^2(I; \mathbb{R}^3)$ such that, with an appropriate inner product $(\cdot, \cdot)_X$ on $H^2(I; \mathbb{R}^3)$,

$$(\partial_t u, v)_X = -\delta E(u)[v], \quad u(0) = u^0,$$

subject to the linearized arclength constraints

$$[\partial_t u]' \cdot u' = 0, \quad v' \cdot u' = 0.$$

Our numerical approximation scheme for the evolution problem is specified via a semi-implicit discretization, i.e., for a step-size $\tau > 0$ and the associated backward difference quotient operator d_t, we compute iterates $(u^k)_{k=0,1,\dots} \subset H^2(I; \mathbb{R}^3)$ via the recursion

$$(d_t u^k, v)_X + \kappa([u^k]'', v'') = -\varrho \delta \mathrm{TP}(u^{k-1})[v]$$

with the constraints

$$[d_t u^k]' \cdot [u^{k-1}]' = 0, \quad v \cdot [u^{k-1}]' = 0.$$

The scheme leads to sparse systems of linear equations in the time steps for cubic C^1 splines and a nodal treatment of the constraints. The explicit treatment of the nonlocal tangent-point functional avoids working with fully populated matrices and furthermore allows for a straightforward parallelization of its computation.

Based on estimates for the second derivative of the tangent-point functional and a uniform bi-Lipschitz radius, we prove a stability result implying energy decay during the evolution as well as maintenance of arclength parametrization. The results are published in the article [2] and provide in combination with the spatial discretization estimates of [1] a quite complete numerical analysis.

We present some numerical experiments exploring the energy landscape, targeted to the question how to obtain global minimizers of the bending energy in knot classes, so-called elastic knots.

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[1] S. Bartels, Ph. Reiter, and J. Riege, A simple scheme for the approximation of self-avoiding inextensible curves, *IMA Journal of Numerical Analysis*, **38**(2), 543–565, 2017.

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Variational flows in heterogeneous media

Andrea Braides

University of Rome “Tor Vergata” (Italy)

We consider gradient-flow type evolutions with underlying energies F_ε depending on a small parameter ε. An effective evolution for such energies as $\varepsilon \to 0$ can be constructed either as the limit of gradient flows at fixed ε or directly using the minimizing-movement approach as in the book of Ambrosio, Gigli and Savaré [1, 2]. If some conditions introduced by Colombo and Gobbino are satisfied then this effective motion can be characterized as a curve of maximal slope of the Γ-limit of F_ε [4] (see also related works [11] and [10] in different contexts). Such conditions are not satisfied if the pattern of local minima is lost in the passage to the limit. This is a usual case for inhomogeneous surface energies, and in particular when dealing with the passage from discrete to continuum.

We will examine some situations when the limit geometric flow can be characterized and shows a different behaviour than the approximating flows. This characterization can be obtained in a simpler way when dealing with crystalline surface energies, in which case we reduce our analysis to a system of ODEs. Example when the limit of motions by crystalline curvature can be studied is when the heterogeneity is derived from an highly oscillating forcing term [6, 9].

We will also examine geometric flows arising as a limit of simple spin systems defined on lattices of spacing ε, whose corresponding energies converge to crystalline energies. In this case, the gradient flow at fixed ε loses meaning, and the minimizing-movement approach must be followed. The limit flow may show pinning by local minima [5, 7], development of bulk microstructure [8], or oscillations of interfaces [3]. In all these cases the limit flow is not easily derived as a geometric flow for some effective energy.

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From initial value problems to some generalized mean field games by convex minimization

Yann Brenier

CNRS, DMA-Ecole Normale Supérieure, Paris (France)

We show that it is possible to solve the initial value problem by a convex optimization problem: i) for short times, in the case of the Euler equations of both incompressible and compressible fluids (and more generally for systems of conservation law admitting a convex entropy), ii) for arbitrarily large time intervals, in the case of Kruzhkov's entropy solutions to the (non-viscous) Burgers equation. The convex minimization problem is related to the concept of sub-solution in the sense of convex integration theory and can also be interpreted as a kind of generalized variational mean-field game.

From the Benjamin–Feir instability to Whitham modulation theory and beyond

Thomas J. Bridges

University of Surrey, Department of Mathematics (UK)

The talk is composed of three parts each of 10-15 minutes. In the first part I will talk about meeting Alexander and the work that emerged on the proof of the Benjamin-Feir (BF) instability [1] and its context. It was the first rigorous proof of the BF instability and continues to have impact in the theory of water waves.

In the second part of the talk two recent important applications of BF instability will be discussed. Firstly, the "Benjamin-Feir index" [2], which is a measure of the local strength of the instability, is being used to construct probability maps of the north Atlantic ocean for forecasting rogue waves, and is applied commercially to the routing of ships. Secondly, a remarkable theory of Elena Tobisch will be discussed whereby the BF instability is used to initiate an energy cascade in conservative systems [3]. It is a mechanism for generating a continuous energy spectrum and a highly complex wave field, starting with a BF instability. Both are having a big impact in applications but are in need of mathematical characterization and analysis.

In the third part of the talk I will discuss recent work which gives a new take on the BF instability. Nonlinear waves, such as Stokes periodic travelling water waves, can be modulated using Whitham theory. However, when characteristics coalesce this theory breaks down. A new theory shows that nonlinear modulation of this coalescence generates a new asymptotically valid two-way Boussinesq equation [4, 5]. The stabilization of the BF instability can be characterized as the implication of coalescing characteristics in Whitham theory. Connecting these two theories, it is then shown that the BF stabilization in shallow water, proved in [1], generates a nonlinear asymptotically-valid two-way Boussinesq equation. This latter discovery is in contrast to the two-way Boussinesq equation proposed by Boussinesq himself for shallow water waves which has been shown to be invalid!

Acknowledgments: The early work [1] was supported by a fellowship from the Humboldt Foundation held at Stuttgart and Hannover, and the more recent work [4] was supported by the UK EPSRC under grant number EP/L505092/1.

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Differential sensitivity in rate independent evolutions

Martin Brokate

TU München, Faculty of Mathematics (Germany)

Rate independent evolutions are inherently nonsmooth. Commonly, they are described via evolution variational inequalities, hysteresis operators, or energetic systems. In this talk we present some progress towards obtaining derivatives of their solution operators with respect to the driving functions and initial conditions, as well as some consequences.

Stress-space relaxation

Sergio Conti(1), **Stefan Müller**(1,2) , **and Michael Ortiz**(1,2,3)

(1) Institut für Angewandte Mathematik, Universität Bonn (Germany)
(2) Hausdorff Center for Mathematics, Universität Bonn (Germany)
(3) Division of Engineering and Applied Science, California Institute of Technology (USA)

The theory of relaxation, based on the concept of quasiconvexity, has been very successful in the study of microstructure in nonlinear elasticity. There are situations, however, in which a formulation with the elastic deformation as the only independent variable is not appropriate, even after minimizing out some internal variables. We consider here a setting in which the natural independent variable is the stress and not the strain field, such as critical-state theory of plasticity. We give a general relaxation framework involving building upon the general tools of $\mathcal{A}$-quasiconvexity [1] and discuss its application to the relaxation of isotropic models in which the yield surface depends on the first two invariants only. Our results can be used to interpret numerical results on fused silica glass [2]

Acknowledgments: This work was partially supported by the Deutsche Forschungsgemeinschaft through the Sonderforschungsbereich 1060 *"The mathematics of emergent effects"*, project A5.

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A minimization approach (in De Giorgi's style) to the wave equation on time-dependent domains

Gianni Dal Maso

SISSA, Trieste (Italy)

We prove the existence of weak solutions to the homogeneous wave equation on a suitable class of time-dependent domains. Using the approach suggested by De Giorgi and developed by Serra and Tilli, such solutions are approximated by minimizers of suitable functionals in space-time.

Global existence and stability for dissipative processes coupled across volume and surface

Karoline Disser

Technische Universität Darmstadt, Fachbereich Mathematik (Germany) and
Weierstraß-Institut Berlin (Germany)

Alexander Mielke and Annegret Glitzky have systematically modelled the dynamics of processes coupled across volume and surface domains using gradient structures [1]. The aim of this talk is to analyze a typical dissipative class of these models and show global well-posedness [2]. The dynamics can be highly nonlinear but the structure of the coupling preserves L^∞-bounds. To show not only existence but also stability based on L^∞-bounds, we use a functional analytic framework based on the isomorphism property of second-order divergence-form operators in $W^{-1,q}$ for $q > d$ larger than the spatial dimension d of the volume domain [3].

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Variational modelling of crystal plasticity — analytical and numerical challenges

Sergio Conti(1) **and Georg Dolzmann**(2)

(1) Universität Bonn, Institut für angewandte Mathematik (Germany)
(2) Universität Regensburg, Fakultät für Mathematik (Germany)

The variational approach to models in finite plasticity proposed in [6, 3] has inspired a large amount of work in the past 20 years. In this talk, we review one of the many facets of the theory, namely the question of macroscopic or effective theories. In particular, for the classical model energy for one slip system proposed in [3] previous numerical experiments in [1, 2] predict the necessity of second-order order laminates in the relaxation. Recent numerical computations in [4, 5] show that third-order laminates are necessary in order to obtain a complete relaxation formula.

Acknowledgments: This work was partially supported by the Deutsche Forschungsgemeinschaft through the Research Unit FOR 797 *"Analysis and computation of microstructure in finite plasticity"*, projects CO 304/4-2 (first author) and DO 633/2-2 (second author) and through the Sonderforschungsbereich 1060 *"The mathematics of emergent effects"*, project A5 (first author)

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The effect of forest dislocations on the evolution of a phase-field model for plastic slip

Patrick Dondl(1), **Matthias Kurzke**(2), **and Stephan Wojtowytsch**(3)

(1) Albert-Ludwigs-Universität Freiburg, Abteilung für Angewandte Mathematik (Germany)
(2) University of Nottingham, School of Mathematical Sciences (UK)
(3) Carnegie Mellon University, Department of Mathematical Sciences, Pittsburgh (USA)

We consider the gradient flow evolution of a phase-field model for crystal dislocations in a single slip system in the presence of forest dislocations. The model is based on a Peierls-Nabarro type energy penalizing non-integer slip and elastic stress. Forest dislocations are introduced as a perforation of the domain by small disks where slip is prohibited.

The Γ-limit of this energy was deduced by Garroni and Müller [1, 2]. Our main result shows that the gradient flows of these Γ-convergent energy functionals do not approach the gradient flow of the limiting energy. Indeed, the gradient flow dynamics remains a physically reasonable model in the case of non-monotone loading.

Our proofs rely on the construction of explicit sub- and super-solutions to a fractional Allen-Cahn equation on a flat torus or in the plane, with Dirichlet data on a union of small discs. The presence of these obstacles leads to an additional friction in the viscous evolution which appears as a stored energy in the Γ-limit, but it does not act as a driving force. In terms of physics, our results explain how in this phase field model the presence of forest dislocations still allows for plastic as opposed to only elastic deformation.

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Oscillatory reaction networks: Far from complex-balance

Bernold Fiedler

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Sustained temporal oscillations are ubiquitous in living and non-living systems. Neural oscillations, heartbeat, nonisothermal catalysis, glycolysis, circadian rhythms, and many other phenomena are examples.

We explore reaction networks, including metabolic and gene regulatory examples, which are not of purely mass action type. We aim for structural conditions on these networks which support autonomous oscillations.

See also

http://dynamics.mi.fu-berlin.de/

Evolution problems for interfaces: Solution concepts and their uniqueness properties

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For many evolution problems for interfaces – like for example the free boundary problem for the Navier-Stokes equation for two immiscible fluids or mean curvature flow – varifold solutions are known to exist globally in time, but the uniqueness of varifold solutions is either unknown or even known to fail in general. At the same time, strong solution concepts are in general limited to local in time existence results due to the development of geometric singularities. In the absence of a comparison principle, the relation between varifold solutions and strong solutions for interfacial evolution problems has remained a mostly open question. We describe a concept of relative entropies for interfacial evolution problems, which enables us to derive a weak-strong uniqueness principle for varifold solutions to the free boundary problem for the Navier-Stokes equation for two immiscible incompressible fluids.

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Spectral stability of inviscid columnar vortices

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The mathematical theory of hydrodynamic stability started in the middle of the 19th century with the study of model examples, such as parallel flows, vortex rings, and surfaces of discontinuity. We focus here on the equally interesting case of columnar vortices, which are axisymmetric stationary flows where the velocity field only depends on the distance to the symmetry axis and has no component in the axial direction. The stability of such flows was first investigated by Kelvin in 1880, for some particular velocity profiles, and the problem benefited from important contributions by Rayleigh in 1880 and 1917. Despite further progress in the 20th century, the only rigorous results available so far are necessary conditions for instability under either two-dimensional or axisymmetric perturbations. The purpose of this talk is to present a recent work in collaboration with D. Smets (Paris), where we prove under mild assumptions that columnar vortices are spectrally stable with respect to general three-dimensional perturbations. The proof relies on a homotopy argument, which allows us to restrict the spectral analysis of the linearized operator to a small neighborhood of the imaginary axis in the complex plane.

A variational approach to model reduction and homogenization in inelastic material systems

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Given an inelastic material model, a structural geometry, and a set of boundary conditions, one can in principle always solve the governing equations to determine the system's mechanical response. However, for large inelastic systems this procedure can quickly become computationally overwhelming, especially in three-dimensions and when the material is locally complex, has microstructure. In such settings multi-scale modeling offers a route to a more efficient model by holding out the promise of a framework with fewer degrees of freedom, which at the same time faithfully represents up to a certain scale the behavior of the system.

In this talk, we present a methodology that produces such models for inelastic systems upon the basis of a variational scheme. The essence of the scheme is the construction of a variational statement for the strain energy as well as the dissipation potential for a coarse scale model in terms of the strain energy and dissipation functions of the fine scale model. From the coarse scale energy and dissipation we can then generate coarse scale material models that are computationally far more efficient than either directly solving the fine scale model or by resorting to FE^2 type modeling. Moreover, the coarse scale model preserves the essential mathematical structure of the fine scale model.

An essential feature for such schemes is the proper definition of the coarse scale inelastic variables. By way of concrete examples, we illustrate the needed steps to generate successful models via application to finite deformation nonlinear viscoelasticity within the microsphere model and by application to problems in classical plasticity.

On convergences of the squareroot approximation scheme to the Fokker–Planck operator

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We study the qualitative convergence behavior [3] of a novel FV-discretization scheme of the Fokker-Planck equation, the squareroot approximation scheme (SQRA), that recently was proposed by [4] in the context of conformation dynamics. We show that SQRA has a natural gradient structure related to the Wasserstein gradient flow structure of the Fokker-Planck equation and that solutions to the SQRA converge to solutions of the Fokker-Planck equation. This is done using a discrete notion of G-convergence for the underlying discrete elliptic operator. The gradient structure of the FV-scheme guaranties positivity of solutions and preserves asymptotic behavior of the Fokker–Planck equation for large times. Furthermore, the SQRA does not need to account for the volumes of cells and interfaces and is taylored for high dimensional spaces. However, based on FV-discretizations of the Laplacian it can also be used in lower dimensions taking into account the volumes of the cells. As an example, in the special case of stationary Voronoi tessellations we use stochastic two-scale convergence to prove that this setting satisfies the G-convergence property. The long term goal of the method is to deal with high dimensional state spaces of large molecules such as in [1]. As a first test, we apply the method to Alanine Dipeptide [2].

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Rate-independent systems in the context of damage and fracture

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Models describing the damage evolution and failure of brittle materials typically belong to the class of rate-independent systems. Such systems have the property that after rescaling (w.r.t. time) the data and solutions in the same way the rescaled solutions solve the rescaled system.

In the first part of the lecture we give a short introduction to rate-independent systems. Of particular interest are systems, where certain underlying energies are not convex. In this case solutions might be discontinuous in time even if the given data is smooth in time. There is an active debate about possible (weak) solution concepts that allow for discontinuities. Suitable jump criteria have to be developed that select trajectories with a physically reasonable jump behavior. We will provide an overview of the most popular solution concepts and illustrate them with some examples.

In the second part of the lecture we transfer these concepts to damage models and discuss the additional analytic challenges that arise for this particular class of models. If time permits we will also address the question of suitable discretization schemes.

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Fractals, homogenization, and multigrid

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The fractal perspective on spatial self-similarity of geological structures has already quite a history, cf., e.g., [6]. Though simulation is obviously needed to overcome observational gaps, current activities in mathematical modelling and numerical approximation of fault network behavior seem to be rare and limited to single faults or simple fault geometries (see, e.g., [5] and the references cited therein).

On this background, we consider a scalar elliptic model problem with jump conditions on a sequence of multiscale networks of interfaces and suggest a new concept, called fractal homogenization, to derive and analyze an associated asymptotic limit problem [2]. The resulting "fractal" solution space is characterized in terms of generalized jumps and gradients, and we prove continuous embeddings into L^2 and H^s, $s < 1/2$ on suitable assumptions on the geometry of the multiscale interface network.

We also present a numerical homogenization strategy in the spirit of [3, 4] which can be regarded as a re-interpretation of well-established concepts for multiscale problems [1] in terms of multigrid methods. We analyze the convergence properties of corresponding iterative solvers as well as the discretization error of corresponding discretization schemes by investigating the stability and approximation properties of certain quasi-projections.

Our theoretical findings are illustrated by numerical computations.

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Relaxation of nonlocal supremal functionals

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Nonlocal functionals in the form of double integrals appear naturally in models of peridynamics. In the homogeneous case, separate convexity of the integrands has been identified as a necessary and sufficient condition for lower semicontinuity [5, 2, 4]. When it comes to relaxation, though, a characterization of the lower semicontinuous envelopes is still largely open. Indeed, in contrast to what one would expect, simple examples in [2, 1] indicate that the relaxed functionals do not follow from separate convexification, and hence, it is unclear whether they can be represented as double integrals.

Motivated by these recent developments, this talk addresses a related question by discussing homogeneous supremal functionals in the nonlocal setting, precisely,

$$L^\infty(\Omega;\mathbb{R}^m) \ni u \mapsto \mathrm{esssup}_{(x,y)\in\Omega\times\Omega} W(u(x), u(y)),$$

with $\Omega \subset \mathbb{R}^n$ a bounded, open set and a continuous density $W : \mathbb{R}^m \times \mathbb{R}^m \to \mathbb{R}$. We show that weak* lower semicontinuity holds if and only if the level sets of a symmetrized and suitably diagonalized version of W are separately convex. It turns out that, unlike for double integrals, the supremal structure of the functionals we consider here is guaranteed to be preserved in the process of relaxation. The proof of this statement relies on the connection between supremal and indicator functionals, which reduces the problem to studying weak* closures of a class of non-local inclusions. We give examples of explicit relaxation formulas for different multi-well functions.

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On the passage from nonlinear to linearized viscoelasticity

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We formulate a quasistatic nonlinear model for nonsimple viscoelastic materials at a finite-strain setting in the Kelvin‘s-Voigt‘s rheology where the viscosity stress tensor complies with the principle of time-continuous frame-indifference. We identify weak solutions in the nonlinear framework as limits of time-incremental problems for vanishing time increment. Moreover, we show that linearization around the identity leads to the standard system for linearized viscoelasticity and that solutions of the nonlinear system converge in a suitable sense to solutions of the linear one. The same property holds for time-discrete approximations and we provide a corresponding commutativity result. This is a joint work with M. Friedrich (Münster).

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Gromov–Hausdorff convergence of discrete optimal transport

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For a natural class of discretisations of a convex domain in $\mathbb{R}^n$, we consider the dynamical optimal transport metric for probability measures on the discrete mesh. Although the associated discrete heat flow converges to the continuous heat flow as the mesh size tends to 0, we show that the transport metric may fail to converge to the 2-Kantorovich metric. Under a strong additional symmetry condition on the mesh, we show that Gromov–Hausdorff convergence to the 2-Kantorovich metric holds.

Cahn–Hilliard models with logarithmic nonlinear terms

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Our aim in this talk is to discuss the Cahn–Hilliard equation and some of its variants with the physically relevant logarithmic nonlinear terms.

Such models have applications in, e.g., phase separation processes in binary alloys, image inpainting and biology.

Hydrodynamic limit and large deviations of reaction-diffusion master equations

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In this talk, I will present a stochastic reaction-diffusion process on a lattice, that combines an exclusion process with the chemical master equation. Particles randomly jump between neighboring lattice sites and can react with each other, when they find themselves at the same lattice position. If the associated chemical reaction network has a detailed-balance equilibrium, then the hydrodynamic limit of the reaction-diffusion process is given by a reaction-diffusion PDE system with a modified mass-action kinetics. The proof uses the entropy method of Guo, Papanicolaou, and Varadhan. The second part concerns dynamic large deviations from the hydrodynamic limit. I will show the large deviations upper bound and, following [2], make the connection between the rate functional and an entropic gradient structure for the reaction-diffusion PDE system.

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Quantitative homogenization in nonlinear elasticity

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We consider a nonlinear elastic composite with a periodic microstructure described by the nonconvex energy functional

$$\int_\Omega W(\tfrac{x}{\varepsilon}, \nabla u(x)) - f(x) \cdot u(x)\, dx.$$

It is well-known that under suitable growth conditions the energy Γ-converges to a homogenized functional with a homogenized energy density W_{hom}. One of the main problems in homogenization of nonlinear elasticity is that long-wavelength buckling prevents the possibility of homogenization by averaging over a single period cell, and thus W_{hom} is in general given by an infinite-cell formula. Under appropriate assumptions on W (frame indifference, minimality at identity, non-degeneracy) and on the microstructure (e.g., a piecewise constant composite with smooth inclusions that might touch), we show that in a neighbourhood of rotations W_{hom} is characterized by a single-cell homogenization formula. In particular, we prove that correctors are available — a property that we exploit to derive a quantitative two-scale expansion and uniform Lipschitz estimates for minimizers. The presentation is based on [1] and work in progress.

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Mass transport in Fokker–Planck equations with tilted periodic potential

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We consider the Fokker-Planck equation

$$\tau \partial_t \rho = \nu^2 \partial_p^2 \rho + \partial_p \big((H'(p) - \sigma) \rho \big) \,, \tag{1}$$

with small parameters τ and ν, where p denotes an internal scalar state variable. It describes the evolution of the probability density $\rho = \rho(t,p)$ of a particle that undergoes a random walk under the influence of the potential H and a force term σ. Here we are interested in the case that H is smooth and periodic, and σ is fixed, such that the effective potential $H_{\text{eff}}(p) = H(p) - \sigma$ is tilted, but still has local minima that represent metastable traps for the particles. Our goal is to derive a simple equation for the dynamics in the limit of vanishing ν and (appropriately chosen) τ.

Since ν is small, ρ develops narrow peaks located at the local minima of H_{eff}, but since $\nu > 0$ the peaks still exchange mass on the Kramer's time scale $c_1 \exp\big(-\frac{c_2}{\nu^2}\big)$, where c_1 and c_2 depend on H and σ. We present a simple approach [HN18] how to derive rigorously in the limit $\nu \to 0$, with $\tau = c_1 \exp\big(-\frac{c_2}{\nu^2}\big)$, the effective limit dynamics for the mass exchange between the local wells.

Our result is closely related to, and also applies to, the case of potentials with two wells that have been studied in [AMP, HN11, PSV10] for symmetric potentials. One advantage of our approach is that it also applies to the case of asymmetric energy landscapes.

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Multipole expansion in random media

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In a homogeneous medium, the far-field generated by a local source is well-described by the multipole expansion, the coefficients of which are given by the moments of the charge distribution. In case of a random medium that homogenizes, this is not covered by standard homogenization theory, since the source lives on a scale comparable to the correlation length. However, the constant-coefficient situation survives, intrinsically interpreted, to some degree: In three space dimensions, the analogy holds up to quadrupoles. This insight allows, for instance, to identify the best artificial boundary conditions for a finite computational domain.

This is joint work with P. Bella & A. Giunti, and with JF. Liu, based on work with J. Fischer.

Onsager reciprocity, gradient flows, and large deviations

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The second law states that in a thermodynamically consistent system the 'entropy' is a Lyapunov function, a function which is monotonic along solutions of the corresponding differential equations. When the system can be written as a gradient flow of the entropy, then this statement is strengthened: not only is this functional monotonic, but it *drives* the dissipative part of the evolution in a precise way, mediated by a 'friction operator'.

In this talk I will go one step further. Onsager already pointed out how symmetry properties of linear friction operators arise through an upscaling procedure from a microscopic-reversibility property of the underlying system. Fluctuations figure centrally in his argument, but at that time their theory was not well developed, and more could not be said.

However, recently we have found that the connection between microscopic reversibility and macroscopic 'symmetry' properties is not at all limited to the close-to-equilibrium, linear-friction-operator context of Onsager's. I will describe how the large-deviation theory of fluctuations allows one to make a much more general statement, where microscopic reversibility is one-to-one coupled to 'symmetry' at the macroscopic level - provided one generalizes the concept of symmetry in an appropriate way.

This is joint work with Michiel Renger and Alexander Mielke (both WIAS, Berlin).

Gradient and GENERIC structures in the space of fluxes

D.R. Michiel Renger

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The chemical reaction rate equation

$$\text{(1)} \qquad \dot\rho_t = \Gamma\bar k(\rho_t), \qquad \bar k_r = k_{r,\mathrm{fw}} - k_{r,\mathrm{bw}}, r \in \mathcal{R},$$

models the evolution of chemical concentrations of different species $\mathcal{Y}$ under a set $\mathcal{R}$ of chemical reactions. Here $k_{r,\mathrm{fw}}, k_{r,\mathrm{bw}}$ are the forward and backward reaction rates and the matrix $\Gamma \in \mathbb{R}^{\mathcal{Y}\times\mathcal{R}}$ contains the stoichiometric coefficients of all reactions.

A classical underlying microscopic model describes the concentration of random reaction particles in a large volume V, which converges as $V \to \infty$ to the solution of (1). The corresponding large-deviation cost for a path to deviate from the expected path can be written as $\int_0^T \hat{\mathcal{L}}(\rho_t, \dot\rho_t)\,dt$ for some cost function $\hat{\mathcal{L}}$. In [2, 3] we showed how this cost can be related to a *generalised gradient system* for the evolution (1) by making the Ansatz that the cost has the form of an energy-dissipation balance:

$$\text{(2)} \qquad \hat{\mathcal{L}}(\rho_t, \dot\rho_t) = \hat\Psi(\rho_t, \dot\rho_t) + \hat\Psi^*\big(\rho_t, -D\hat{\mathcal{F}}(\rho_t)\big) + \langle D\hat{\mathcal{F}}(\rho_t), \dot\rho_t\rangle.$$

More information about microscopic fluctuations can be retrieved by studying particle/reaction net fluxes, i.e. by bookkeeping the amount W_t^V of forward minus backward reactions that have taken place up to time t. The concentrations can be retrieved from the fluxes via the continuity equation $\rho_t^V = \rho_0^V + \Gamma W_t^V$. Now the large-particle limit evolution is $\dot w_t = \bar k(\rho_t)$, with corresponding large-deviation cost $\int_0^T \mathcal{L}(w_t, \dot w_t)\,dt$ [4].

It turns out that for a network of fast and slow reactions, the flux cost can induce a *generalised GENERIC structure* in the spirit of [1], similarly to (2):

$$\text{(3)} \qquad \mathcal{L}(w_t, \dot w_t) = \Psi(w_t, \dot w_t - L(w_t)D\mathcal{E}(w_t)) + \Psi^*\big(w_t, -D\mathcal{F}(w_t)\big) + \langle D\mathcal{F}(w_t), \dot w_t\rangle,$$

the Hamiltonian part $LD\mathcal{E}$ corresponds to the fast reactions whereas the dissipative elements $\Psi, \Psi^*, \mathcal{F}$ correspond to the slow reactions.

From the fact that the two cost functions are related by a *contraction principle* $\hat{\mathcal{L}}(\rho, s) = \inf_{\rho=\rho_0+\Gamma w, s=\Gamma j} \mathcal{L}(w, j)$, we can in fact derive a more general theory about the relation of gradient/GENERIC structures in the space of fluxes with gradient/GENERIC structures in the space of concentrations [5].

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Recent advances in diffuse interface tumor growth analysis

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We consider the problem of long-time behavior of solutions and optimal control for a diffuse interface model of tumor growth. The state equations couple a Cahn-Hilliard equation and a reaction-diffusion equation, which models the growth of a tumor in the presence of a nutrient and surrounded by host tissue. The introduction of drugs into the system through the nutrient serves to eliminate the tumor cells, hence, in this setting the control variable will act on the nutrient equation. Furthermore, we allow the objective functional to depend on a free time variable, which represents the unknown treatment time to be optimized. As a result, we obtain first order necessary optimality conditions for both the drug concentration and the treatment time. One of the main aim of the control problem is to realize in the best possible way a desired final distribution of the tumor cells which is expressed by a target function that can be taken as a stable configuration of the system, so that the tumor does not grow again once the treatment is completed. In view of this fact we consider here also the problem of long-time behavior of solutions.

This is a joint project with C. Cavaterra (University of Milan), A. Miranville (University of Poitiers), G. Schimperna (University of Pavia), H. Wu (Fudan University, Shanghai).

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Visco-Energetic solutions to rate-independent systems, with applications to finite-strain plasticity and brittle fracture

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Visco-Energetic solutions to rate-independent systems have been recently obtained [3] by passing to the time-continuous limit in a time-incremental scheme, akin to that for Energetic solutions [1], but perturbed by a 'viscous' correction term, as in the case of Balanced Viscosity solutions [2]. However, for Visco-Energetic solutions this viscous correction is tuned by a fixed parameter. The resulting solution notion is characterized by a stability condition and an energy balance analogous to those for Energetic solutions, but, in addition, it provides a fine description of the system behavior at jumps as Balanced Viscosity solutions do. Visco-Energetic evolution can be thus thought as 'in-between' Energetic and Balanced Viscosity evolution, cf. [4].

We will explore these aspects in a general metric framework. We will then illustrate the application of the Visco-Energetic concept to models for finite-strain plasticity (cf. [5]) and for the evolution of brittle fractures. The talk reflects joint collaborations with Gianni Dal Maso, Giuseppe Savaré, and Rodica Toader.

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Dynamical problems in continuum mechanics of solids at large strains

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Deformable solids at large strains uses material reference (Lagrange) description which leads or may lead to mathematically amenable problems. In dynamical situations, one must rely on differential equations rather than on variational principles for some functionals as in the (quasi)static situations, which brings many difficulties.

Various gradient theories are thus to be employed. In particular, the concept of nonsimple (possibly nonlocal) materials seems essential to obtain global existence results for frame-indifferent models, possibly accounting for at least local non-interpenetration. Besides the desired regularization analytical effects, in linearized situations these higher-order terms lead to anomalous or possibly also normal dispersion of elastic waves.

In some situations, the reference configuration does not have any real meaning, and only the actual deformed configuration is relevant. Then all transport tensors (like mobility of diffusants in poroelastic materials or heat conductivity) must be pulled back. Yet, the analysis of such coupled systems is known only in particular situations [1], cf. e.g. the only quasistatic model in [3] of thermal coupling in Kelvin-Voigt materials while full dynamical variant seems difficult.

When there are some internal variables considering with gradient theories (as plasticity or damage or capillarity in the Cahn-Hilliard model), these gradients are also to be considered rather as pulled back. This gives rise to a Korteweg-like stress and to additional difficulties, not always successfully solved so far.

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Entropic regularization of optimal transport and mean field planning

Giuseppe Savaré

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First order mean field planning problems can be characterized by a nonlinear system of a Hamilton-Jacobi equation coupled with a continuity equation for the nonnegative density distribution m

$$\text{(MFPP)} \qquad \begin{cases} -\partial_t u + H(x, Du) = f(x, m) & \text{in } (0,1)\times\mathbb{R}^d, \\ \partial_t m - \nabla\cdot(m\, H_{\boldsymbol{p}}(x, Du)) = 0 & \text{in } (0,1)\times\mathbb{R}^d, \\ m(0,\cdot) = m_0,\ m(1,\cdot) = m_1 & \text{in } \mathbb{R}^d, \end{cases}$$

with prescribed initial and final boundary condition at $t = 0, 1$. In the framework of mean field game theory [3], the planning problem was suggested and developed by P.-L. Lions in his courses at Collège de France.

(MFPP) can be interpreted as the first order optimality condition of the following minimization problem in $(0,1)\times\mathbb{R}^d$

$$\min \iint \big[L(x, \boldsymbol{v})\, m + F(x, m)\big]\, \mathrm{d}x\, \mathrm{d}t \ :\ \boldsymbol{v} \in L^2(m\, \mathrm{d}x\mathrm{d}t), \quad \begin{cases} \partial_t m + \nabla\cdot(m\, \boldsymbol{v}) = 0 \\ m(0,\cdot) = m_0\,, m(1,\cdot) = m_1, \end{cases}$$

which is the entropic regularization (by the primitive F of f) of the dynamic optimal transportation problem [2, 1, 4], whose Lagrangian cost L is the Fenchel conjugate of the Hamiltonian H. The structure of (MFPP) naturally arises from the coupling with the dual problem

$$\max \int u_0 m_0\, \mathrm{d}x - \int u_1 m_1\, \mathrm{d}x - \iint F^*(\alpha)\, \mathrm{d}x\, \mathrm{d}t,$$

$$\text{under the constraint} \quad -\partial_t u + H(x, Du) \le \alpha \quad \text{in } (0,1)\times\mathbb{R}^d.$$

By using some ideas and techniques of optimal transport theory, minimax duality, and dynamic superposition principles, we will discuss the well posedness of both the variational problems in a suitable functional setting, their strong duality, and their link with an appropriate measure-theoretic formulation of (MFPP).
(In collaboration with Carlo Orrieri and Alessio Porretta).

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Characterizations of symmetric polyconvex functions

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The notion of symmetric quasiconvexity plays a key role for energy minimization in the setting of geometrically linear elasticity theory. Due to the complexity of the former, a common approach is to retreat to necessary and sufficient conditions that are easier to handle. Based on [1], I will focus on the sufficient condition of symmetric polyconvexity in this talk. I will present characterizations of symmetric polyconvexity in two and three dimensions and show related results on symmetric polyaffine functions and symmetric polyconvex quadratic forms. In particular, I will present an example of a symmetric rank-one convex quadratic form in 3d that is not symmetric polyconvex. The construction of this example is inspired by the famous work by Serre from 1983 on the classical situation without symmetry. Beyond their theoretical interest, our findings on symmetric polyconvexity may turn out useful for computational relaxation and homogenization.

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One-dimensional nonlinear viscoelasticity with limited strain

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We are interested in finding solutions of nonlinear differential equations describing the behaviour of one-dimensional viscoelastic medium with implicit constitutive relations. We focus on a subclass of such models known as the strain-limiting models introduced by Rajagopal [1, 2, 3]. To describe the response of viscoelastic solids we assume a nonlinear relationship among the linearized strain, the strain rate and the Cauchy stress. We first look at traveling wave solutions that correspond to the heteroclinic connections between the two constant states, and establish conditions for the existence of such solutions, and find them explicitly, implicitly or numerically, for various forms of the non-linear constitutive relation [4]. Then we consider corresponding Cauchy and boundary-value problems from both modelling and analysis points of view.

Acknowledgments: This work is partially supported by TÜBİTAK-1001 Grant 116F093.

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Well-posedness, regularity, and optimal control of general Cahn–Hilliard systems with fractional operators

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In this lecture, we consider general systems of Cahn–Hilliard type of the form

$$\partial_t y + A^{2r} \mu = 0, \tag{1}$$

$$\tau\, \partial_t y + B^{2\sigma} y + f_1'(y) + f_2'(y) = \mu + u, \tag{2}$$

$$y(0) = y_0. \tag{3}$$

Here, A and B are linear, unbounded, selfadjoint, and positive operators having compact resolvents, and A^{2r} and $B^{2\sigma}$, where $r > 0$ and $\sigma > 0$, denote fractional powers in the spectral sense of A and B, respectively. The unknowns μ and y stand for the chemical potential and the order parameter in an isothermal phase separation process taking place in a container in $\mathbb{R}^3$, while u denotes a distributed control function. Moreover, the functions f_1 and f_2 are such that $f = f_1 + f_2$ is a double-well potential; in this connection, f_1 is a convex function, and f_2 is typically a smooth concave perturbation.

In our analysis, we report about results for the system (1)–(3) concerning existence, uniqueness, regularity, and optimal control that have recently been established in the papers [1, 2, 3].

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Mixed Lagrangian-Eulerian formulations

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In presence of finite strains, reference and actual configurations need to be distinguished. This is particularly relevant when mechanics is combined with other effects, requiring to simultaneously deal with both Lagrangian and Eulerian variables. Magnetoelastic materials are a first example in this direction, for the energy is defined in terms of deformation (Lagrangian) and magnetization (Eulerian). Other examples are nematic polymers, where the Eulerian variable is the nematic orientation, and piezoelectrics, which involve the Eulerian polarization instead. In fact, an interplay of Lagrangian and Eulerian effects occurs already in case of space-dependent forcings, as well as in some specific models of finite plasticity, where plastic deformations compose with the elastic ones. Mixed Lagrangian-Eulerian formulations arise in fluid-structure interaction, where the deformed body defines the (complement of the) fluid domain, and in solid-solid phase change, in case actual phase interphases are considered. I will present some classical and recent results on the topic.

Coexistence of Hamiltonian-like and dissipative dynamics in chains of coupled oscillators

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We consider rings of coupled phase oscillators with anisotropic coupling. When the coupling is skew-symmetric, i.e. when the anisotropy is balanced in a specific way, the system shows robustly a coexistence of Hamiltonian-like and dissipative regions in the phase space. We relate this phenomenon to the time-reversibility property of the system. The geometry of low-dimensional systems up to five oscillators is described in detail. In particular, we show that the boundary between the dissipative and Hamiltonian-like regions consists of families of heteroclinic connections. For larger chains with skew-symmetric coupling, some sufficient conditions for the coexistence are provided, and in the limit of $N \to \infty$ oscillators, we formally derive an amplitude equation for solutions in the neighborhood of the synchronous solution. It has the form of a nonlinear Schrödinger equation and describes the Hamiltonian-like region existing around the synchronous state similarly to the case of finite rings.

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On fluctuations in particle systems and their links to macroscopic models

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We study particle systems and analyse their fluctuations. These fluctuations can be described by stochastic differential equations or variational formulations related to large deviations. In particular, recently a *canonical structure* has been introduced [6, 7] to describe dynamical fluctuations in stochastic systems. The resulting theory has several attractive features: Firstly, it applies to a wide range of systems, including finite-state Markov chains and Macroscopic Fluctuation Theory (MFT) [1], see [4]. Secondly, it is based on an *action functional* which is a relative entropy between probability measures on path spaces — this means that it provides a variational description of the systems under consideration, and the action can be related to large deviation rate functionals. Thirdly, it extends the classical Onsager-Machlup theory [9] in a natural way, by replacing the quadratic functionals that appear in that theory with a pair of convex but non-quadratic Legendre duals Ψ and $\Psi^{\star}$. We will discuss how this structure can be applied to any finite-state Markov chain and provides a unifying formulation of a wide range of systems [4]. We will discuss large-scale limits of particle systems, closely related to the Energy-Dissipation-Principle, see e.g. [5, 2, 3, 8].

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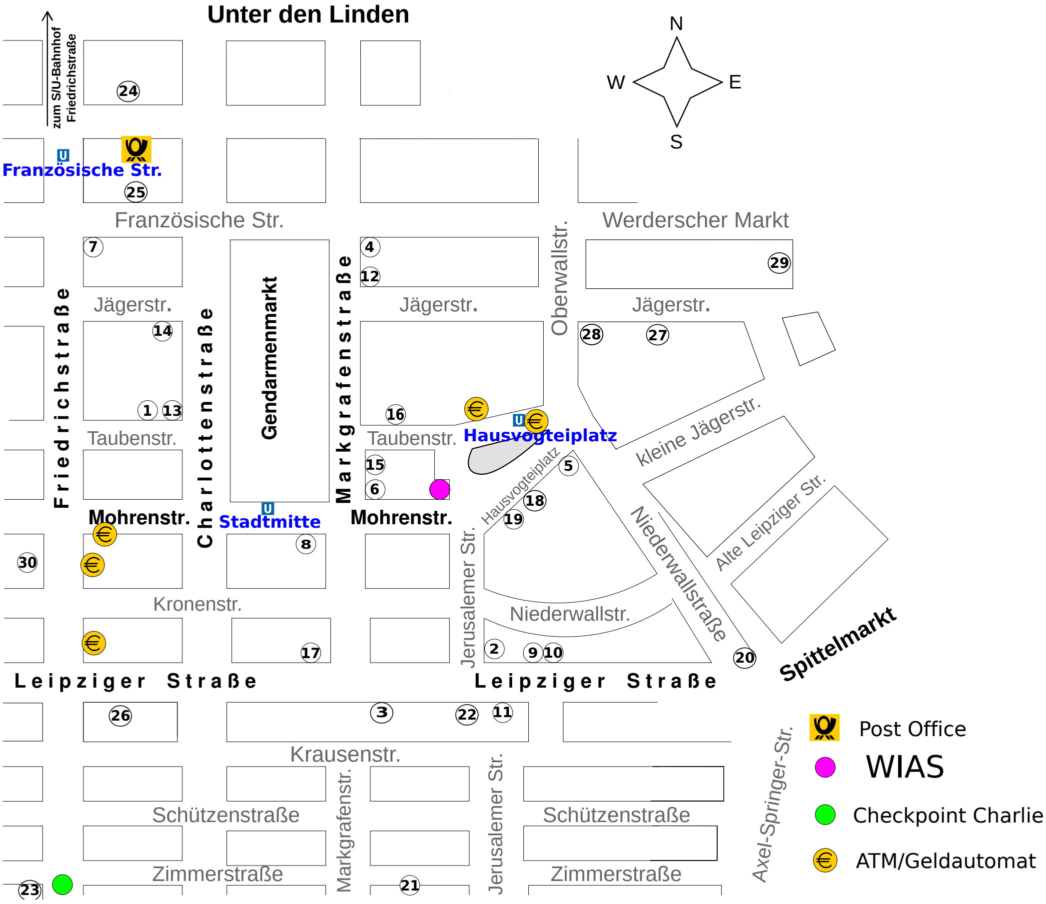
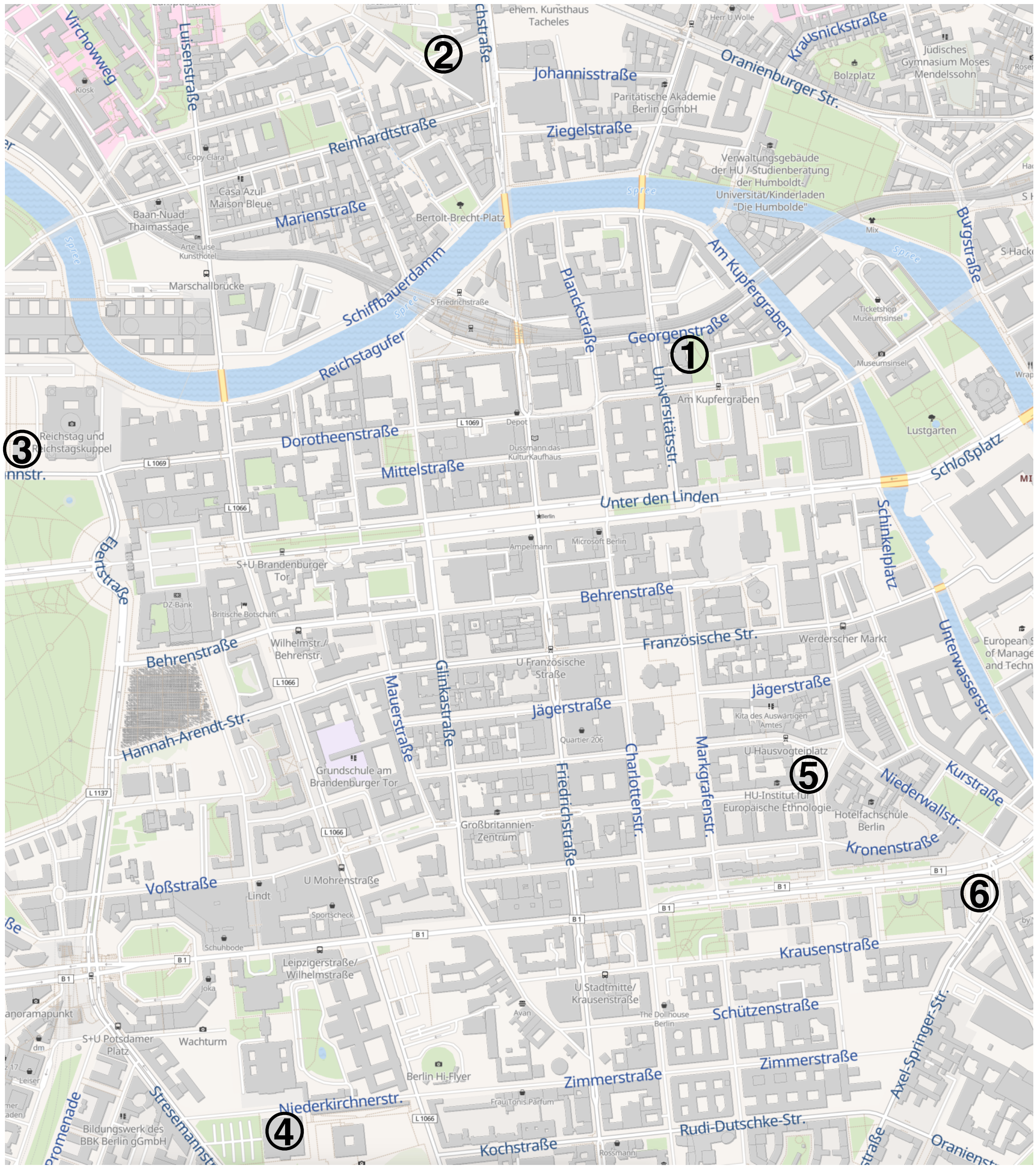
PLACES TO HAVE LUNCH/DINNER

The following list contains a selection of places to eat and drink in the vicinity of WIAS. Many WIAS staff members spend their lunch break in the canteen of Konzerthaus am Gendarmenmarkt (number (1) in the list). The entrance is via Taubenstraße, 2nd floor.



1	Mensa Konzerthaus
2	Bistro Vital
3	Supermarkt
4	Bistro am Gendarmenmarkt
5	The coffee shop
6	Kaffee Einstein
7	Galéries Lafayette
8	Hilton
9	Fontana di Trevi Ristorante
10	Irish Times
11	China-City Restaurant
12	Amici am Gendarmenmarkt
13	Lutter und Wegner
14	Augustiner am Gendarmenmarkt
15	Shan Rahimkan Café
16	Brasserie
17	Löwenbräu
18	Good Time
19	Steinecke (bakery)
20	Farmer's Market
21	Springer Building
22	Döner
23	Mc Donalds
24	Subway
25	Borchard
26	Otito Vietnamese Food
27	Chipps
28	Lunch Time
29	Town Bar
30	Leopold's Kontorhaus

SOCIAL PROGRAM AND COLLOQUIUM



(1) Humboldt-Universität zu Berlin
Universitätsgebäude am Hegelplatz
Dorotheenstraße 24
Lecture room 1.101

(2) Restaurant Casalot
Claire-Waldoff-Straße 5
Dinner starts at 7.00 pm

(3) Deutscher Bundestag
Platz der Republik 1
Meeting point: White containers at 8.15 am
Please do not forget your ID/passport!

(4) Gropius Bau
Niederkirchnerstraße 7
Tour starts at 10.30 am

(5) WIAS Berlin
Mohrenstraße 39
Nearest subway: Hausvogteiplatz (U2)

(6) Motel One
Leipziger Str. 50
Nearest subway: Spittelmarkt (U2)

We suggest the following routes to the Bundestag (3) and Gropius Bau (4) from the Motel One (6):

- **Bundestag:** Take the subway from U-Bhf Spittelmarkt to S+U-Bhf Potsdamer Platz (6 min). From there, you can walk along Ebertstraße (passing the Holocaust memorial and the Brandenburger Tor) to the north (15 min).
- **Gropius Bau:** Take the subway from U-Bhf Spittelmarkt to S+U-Bhf Potsdamer Platz (6 min). From there walk along Stresemannstraße (200 m) and then turn left into Niederkirchnerstraße (170 m). Alternatively, you can walk from Motel One along Axel-Springer-Straße (350 m) and then turn right into Zimmerstraße which you follow for 1.1 km. This takes about 20 min.

Workshop dinner

The workshop dinner starts at 7pm and takes place at the Restaurant Casalot

Restaurant Casalot (number 2 in the map above),
Claire-Waldoff-Straße 5,
10117 Berlin.

The restaurant is within walking distance of the Humboldt-Universität zu Berlin (approx. 1 km, about 10 Minutes).

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>09:00-09:15</td><td></td><td rowspan="3">Schlömer-kemper</td><td rowspan="15">Social event</td><td rowspan="2"></td><td rowspan="2">Abels</td></tr>
<tr><td>09:15-09:30</td><td>Opening</td></tr>
<tr><td>09:30-09:45</td><td rowspan="3">Rossi</td><td rowspan="3">Savaré</td><td rowspan="2">Dondl</td></tr>
<tr><td>09:45-10:00</td><td rowspan="2">Kružík</td></tr>
<tr><td>10:00-10:15</td><td rowspan="2">Disser</td></tr>
<tr><td>10:15-10:30</td><td rowspan="2">Bartels</td><td rowspan="2">Roubíček</td><td rowspan="2">Rocca</td></tr>
<tr><td>10:30-10:45</td><td rowspan="2">Coffee break</td></tr>
<tr><td>10:45-11:00</td><td rowspan="2">Coffee break</td><td rowspan="2">Coffee break</td><td rowspan="2">Coffee break</td></tr>
<tr><td>11:00-11:15</td><td rowspan="2">Braides</td></tr>
<tr><td>11:15-11:30</td><td rowspan="2">Heida</td><td rowspan="2">Şengül</td><td rowspan="2">Zimmer</td></tr>
<tr><td>11:30-11:45</td><td rowspan="2">Hackl</td></tr>
<tr><td>11:45-12:00</td><td rowspan="2">Kornhuber</td><td rowspan="2">Kreisbeck</td><td rowspan="2">Renger</td></tr>
<tr><td>12:00-12:15</td><td rowspan="3">Dal Maso</td></tr>
<tr><td>12:15-12:30</td><td rowspan="2">Neukamm</td><td rowspan="8">Lunch break</td><td rowspan="2">Mittnenzweig</td></tr>
<tr><td>12:30-12:45</td></tr>
<tr><td>12:45-13:00</td><td rowspan="6">Lunch break</td><td rowspan="6">Lunch break</td><td rowspan="6">Lunch break</td><td>Closing</td></tr>
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<tr><td>13:30-13:45</td></tr>
<tr><td>13:45-14:00</td></tr>
<tr><td>14:00-14:15</td></tr>
<tr><td>14:15-14:30</td><td rowspan="3">Otto</td><td rowspan="3">Brenier</td><td rowspan="2">Greeting</td><td rowspan="3">Gallay</td></tr>
<tr><td>14:30-14:45</td></tr>
<tr><td>14:45-15:00</td><td rowspan="3">Stefanelli</td></tr>
<tr><td>15:00-15:15</td><td rowspan="2">Maas</td><td rowspan="2">Niethammer</td><td rowspan="2">Yanchuk</td></tr>
<tr><td>15:15-15:30</td></tr>
<tr><td>15:30-15:45</td><td rowspan="2">Coffee break</td><td rowspan="2">Coffee break</td><td rowspan="3">Coffee break</td><td rowspan="2">Coffee break</td></tr>
<tr><td>15:45-16:00</td></tr>
<tr><td>16:00-16:15</td><td rowspan="2">Fischer</td><td rowspan="2">Conti</td><td rowspan="3">Bridges</td></tr>
<tr><td>16:15-16:30</td><td rowspan="3">Knees</td></tr>
<tr><td>16:30-16:45</td><td rowspan="2">Sprekels</td><td rowspan="2">Dolzmann</td></tr>
<tr><td>16:45-17:00</td><td rowspan="2">Fiedler</td></tr>
<tr><td>17:00-17:15</td><td rowspan="2">Miranville</td><td rowspan="2">Brokate</td><td rowspan="3">Peletier</td></tr>
<tr><td>17:15-17:30</td><td rowspan="3"></td></tr>
<tr><td>17:30-17:45</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>17:45-18:00</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Dinner 19:00</td><td></td><td></td></tr>
</table>