WORKSHOP NONLINEAR EVOLUTIONARY EQUATIONS AND APPLICATIONS

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Contents

1. Plenary talks

1.1. **Clément Cancès, INRIA Lille.**

On a thermodynamically consistent (reduced) model for iron corrosion.
In dedicated repositories, nuclear wastes are set in iron canister and then stored in an aqueous environment. An accurate modeling of the corrosion of iron is therefore mandatory to evaluate the degradation of the iron, and overall to estimate the production of hydrogen stemming from the chemical reaction. In this talk, we are interested in the evolution fo the oxide layer (magnetite) at the surface of an iron block surrounded by an aqueous solution. In the simplified model I will present, charge carriers (iron cations, electrons) are transported in the oxide layer. We pay attention to the fact that our model is consistent with the second principle of thermodynamics, in opposition to the reference model in the state of the art. Thanks to the decay of some free energy, we show the global in time existence of a solution to the problem. This work has been done in collaboration with Claire Chainais-Hillairet, Benoît Merlet, Federica Raimondi, and Juliette Venel.

1.2. **Li Chen, University of Mannheim.**

Rigorous Derivation of the Degenerate Parabolic-Elliptic Keller-Segel System from a Moderately Interacting Stochastic Particle System.
The main goal of this thesis is a rigorous derivation of the degenerate parabolic-elliptic Keller-Segel system of porous medium type on the whole space $\mathbb{R}^d$ from a moderately interacting stochastic particle system. After we review some existing results on this topic and introduce the setting of the problem as well as main results of this thesis, we establish the classical solution theory of degenerate parabolic-elliptic Keller-Segel system and its non-local version. This classical solution theory is used later to obtain required estimates on the particle level. Since the interaction potential contains singularity, we perform an approximation of the stochastic moderately interacting particle system using the cut-offed potential. Then, we compare this new system with another cut-offed system of mean-field type. In this thesis we present two different scaling results, namely using logarithmic scaling we obtain convergence in expectation and in the

algebraic scaling we deduce convergence in probability. Combining the estimates on the level of partial differential equations and on the particle level we obtain propagation of chaos result. This is a joint work with Veniamin Gvozdik, Alexandra Holzinger, and Yue Li.

1.3. **Manuel Friedrich, FAU Erlangen.**

Nonlinear and linearized models in thermoviscoelasticity.
In this talk, I present a quasistatic nonlinear model in thermoviscoelasticity at a finite-strain setting in the Kelvin-Voigt rheology where both the elastic and viscous stress tensors comply with the principle of frame indifference under rotations. The force balance is formulated in the reference configuration by resorting to the concept of non-simple materials whereas the heat transfer equation is governed by the Fourier law in the deformed configurations. Weak solutions are obtained by means of a staggered in-time discretization where the deformation and the temperature are updated alternatingly. Our result refines a recent work by Mielke and Roubicek since our approximation does not require any regularization of the viscosity term. Afterwards, we focus on the case of deformations near the identity and small temperatures, and we show by a rigorous linearization procedure that weak solutions of the nonlinear system converge in a suitable sense to solutions of a system in linearized thermoviscoelasticity. Based on joint work with Rufat Badal (Erlangen) and Martin Kruzik (Prague).

1.4. **Ansgar Jüngel, TU Vienna.**

Cross-diffusion systems with entropy structure.
Many applications in physics and biology, like segregation of population species, fluid mixtures, and tumor growth, can be described on the macroscopic level by so-called cross-diffusion systems, which are systems of strongly coupled parabolic equations. Often, the diffusion matrix of these models is neither symmetric nor positive definite, but the formulation in terms of entropy variables yields a positive semidefinite mobility matrix. This formulation reveals a formal gradient-flow or entropy structure. The talk introduces to entropy methods used to analyze cross-diffusion systems, including equations with nonstandard degeneracies. Results comprise the global existence of solutions, their boundedness and large-time behavior as well as weak-strong uniqueness. The use of entropy methods is very extensive, and it can be applied even to problems with stochastic noise terms.

1.5. **Tim Laux, HCM Bonn.**

The large-data limit of the MBO scheme for data clustering.
The MBO scheme is an efficient scheme for data clustering, the task of partitioning a given dataset into several clusters. In this talk, I will present a rigorous analysis of this scheme in the large data limit. Each iteration of the MBO scheme corresponds to one step of implicit gradient descent for the thresholding energy on the similarity graph of the dataset. For a subset of the nodes of the graph, the thresholding energy measures the amount of heat transferred from the subset to its complement. It is then natural to think that outcomes of the MBO scheme are (local) minimizers of this energy. We prove

that the algorithm is consistent, in the sense that these (local) minimizers converge to (local) minimizers of a suitably weighted optimal partition problem.
This is joint work with Jona Lelmi (U Bonn).

1.6. **Daniel Matthes, TU Munich.**

Exponential equilibration in cross-diffusion systems with gradient flow structure.
The probably most famous result on gradient flows in the Wasserstein metric is the one about exponential equilibration in nonlinear Fokker-Planck equations: if the nonlinearity satisfies McCann's convexity hypothesis, and the potential is confining of uniform strength L, then any solution goes to equilibrium at rate $\exp(-Lt)$. Various generalizations of this result have been proven in the past two decades, e.g. to PDEs of fourth order, with non-local interaction etc. However, no result of comparable generality and simplicity exists for the seemingly easy situation in which two Fokker-Planck equations are coupled by means of (arbitrarily small) cross diffusion.
In this talk, we explain why the original proof via convexity arguments necessarily breaks down, no matter how tame the cross diffusion coupling is. Our main result shows that the coupled system still equilibrates at exponential rate, but with a slightly slower rate $\exp(-(L-k)t)$ where k measures the coupling strength. The proof combines "residual convexity" with more hands-on variational methods in the style of singular perturbation theory.
This is joint work with Lisa Beck (Augsburg) and Martina Zizza (SISSA).

1.7. **Alexander Mielke, WIAS and HU Berlin.**

Convergence of a split-step scheme for gradient flows with a sum of two dual dissipation potentials.
A gradient systems $(\mathbf{X}, \mathcal{E}, \mathcal{R})$ is a triple consisting of a state space $\mathbf{X}$ (typically a separable, reflexive Banach space), an energy or entropy functional $\mathcal{E} : \mathbf{X} \to \mathbb{R} \cup \{\infty\}$, and a dissipation potential $\mathcal{R} : \mathcal{X}_1 \times \mathcal{X} \to [0, \infty]$. The latter means that $\mathcal{R}(u, \cdot) : X \to [0, \infty]$ is convex, lower semicontinuous, and satisfies $\mathcal{R}(u, 0) = 0$. The associated gradient-flow equation is given by

$$0 \in \partial_{\dot{u}} \mathcal{R}(u, \dot{u}) + \mathrm{D}\mathcal{E}(u) \quad \text{or equivalently} \quad \dot{u} \in \partial_\xi \mathcal{R}^*\Big(u, -\mathrm{D}\mathcal{E}(u)\Big).$$

We are interested in the situation that the dual dissipation potential $\mathcal{R}^*$ is a sum of two different dual dissipations potentials, namely $\mathcal{R}^* = \mathcal{R}_1^* + \mathcal{R}_2^*$. Applications are reaction-diffusion systems $\dot{u} = \mathrm{div}(\delta \nabla u)u - \alpha u$, where

$$\mathcal{E}(u) = \int_\Omega \frac{1}{2} u^2 \,\mathrm{d}x \quad \text{and} \quad \mathcal{R}^*(u, \xi) = \int_\Omega \Big(\frac{\delta}{2} |\nabla \xi|^2 + \frac{\alpha}{2} \xi^2\Big) \mathrm{d}x.$$

We investigate the questions under what assumption the split-step algorithm

$$\begin{aligned} &\dot{u} \in 2\partial_\xi \mathcal{R}_1^*\Big(u, -\mathrm{D}\mathcal{E}(u)\Big) && \text{for } Nt \in [0, 1/2[\mod 1, \\ &\dot{u} \in 2\partial_\xi \mathcal{R}_2^*\Big(u, -\mathrm{D}\mathcal{E}(u)\Big) && \text{for } Nt \in [1/2, 1[\mod 1, \end{aligned}$$

converges for $N \to \infty$. We give an example showing that convergence does not hold if $\mathcal{E}$ is only convex but not differentiable. For differentiable, semiconvex functionals $\mathcal{E}$ and dissipation potentials satisfying the upper and lower estimates

$$\mathcal{R}_i(v) \geq \psi(\|v\|), \quad \mathcal{R}_i^*(\xi) \geq \psi(\|\xi\|_*), \quad \mathcal{R}_i(v) + \mathcal{R}_i^*(\xi) \geq c_0\|v\| \, \|\xi\|_*$$

for a superlinear function ψ and a $c_0 > 0$.
This is joint work with Riccarda Rossi (U Brescia) and Artur Stephan (WIAS).

1.8. **André Schlichting, WWU Münster.**

Gradient structures and tilting.
Many gradient systems are tilt-dependent, meaning that a change in the driving functional does not lead to a change in the dissipation potential. Such tilt dependence separates the driving functional from the dissipation potential, guarantees a clear model interpretation, and leads to strong convergence concepts of gradient systems.
However, many discrete and nonlocal functions are tilt dependent. We show that this is natural by studying the classical example of the Kramers limit with high activation energy, where a diffusion converges to a jump process and the Wasserstein gradient system converges to a Cosh-type system. We show and explain how the gradient independence of the pre-limit system is lost in the limit system.
This is a joint work with Mark Peletier (TU Eindhoven).

1.9. **Marie-Therese Wolfram, University of Warwick.**

Collective dynamics in the social and data sciences.
Collective dynamics can be observed in many situations in our daily lives, for example the motion of bird flocks, the formation of directional lanes in pedestrian flows or opinion dynamics on social media. In all these examples interactions among individuals lead to the formation of complex phenomena in the entire population. In this talk I will discuss different mathematical models to describe large interacting particle systems and how ideas from collective dynamics can be used to solve global optimisation problems arising in the context of data science. I will then focus on the respective macroscopic equations, which often have a gradient flow structure. This structure can be used to analyse the large time behaviour, in particular the equilibration speed as well as the form of equilibrium solutions.

2. Contributed talks

2.1. **Jean Cauvin-Vila, INRIA Paris.**

A Cross-Diffusion Cahn-Hilliard system: existence and numerics.
I will present a Cahn-Hilliard model for a multicomponent mixture with cross-diffusion effects and degenerate mobility introduced by V. Ehrlacher, J.-F. Pietschmann and G. Marino in 2020. The main originality of the model stems from the fact that only one species tends to separate from the others. The authors proved existence of weak solutions and I will briefly goes through the main difficulties in the proof. Then, I will introduce a finite-volume scheme for the model, explain its main properties (preservation of constraints, decrease of the discrete entropy...) and present numerical results. If time allows, I will hint at the main difficulties in the convergence analysis, which are the discrete counterparts of the analytical difficulties at the continuous level. This is an ongoing work with the previously cited authors.

2.2. **Jakob Fuchs, TU Dortmund.**

Strong Convergence of the Thresholding Scheme for the Mean Curvature Flow of Mean Convex Sets.
Bence, Merriman and Osher's thresholding scheme is a time discretization of mean curvature flow. I restrict to the two-phase setting and mean convex initial conditions. In the sense of the minimizing movements interpretation of Esedoglu and Otto, I show the time-integrated energy of the approximation to converge to the time-integrated energy of the limit. As a corollary, the conditional strong convergence results of Laux and Otto become unconditional in this case. The results are general enough to handle the extension of the scheme to anisotropic flows for which a non-negative kernel can be chosen.

2.3. **Stefanos Georgiadis, KAUST & TU Vienna.**

Asymptotic derivation of multicomponent compressible flows with heat conduction and mass diffusion.
In this talk, we focus on a type-I system modeling non-isothermal multicomponent flows that include the effects of mass-diffusion and heat conduction but no viscous effects. First, we show how the model is obtained via a Chapman-Enskog expansion of a type-II model. The second step is to use the dissipative structure of the system, in order to verify that it fits into the general framework of systems of hyperbolic-parabolic type. Third, we derive a relative entropy identity, which is used in order to prove convergence of strong solutions of the original system, to strong solutions of heat-conducting multicomponent Euler flows when the mass-diffusivity tends to zero. Also to prove convergence to smooth solutions of multicomponent adiabatic Euler flows when both heat conductivity and mass diffusivity tend to zero. Finally, we show the global-in-time existence of weak solutions for the parabolic counterpart of the system, obtained by setting the barycentric velocity equal to zero.
This is a joint work with Ansgar Jüngel (TU Wien) and Athanasios Tzavaras (KAUST).

2.4. **Umberto Guarnotta, University of Palermo.**

On a non-homogeneous parabolic equation with singular and convective reaction.
The talk is devoted to present an existence result for the following problem:

$$\begin{cases} u_t - \operatorname{div} a(\nabla u) = f(x,u) + g(x,\nabla u) & \text{in } \Omega \times (0,T) \\ u > 0 & \text{in } \Omega \times (0,T) \\ u = 0 & \text{on } \partial\Omega \times (0,T) \\ u(x,0) = u_0(x) & \text{in } \Omega \times \{0\} \end{cases} \tag{P}$$

where $\Omega \subset \mathbb{R}^N, N \geq 2$, is a bounded domain. The differential operator $u \mapsto \operatorname{div} a(\nabla u)$, usually called a-Laplacian, is patterned after the (p,q)-Laplacian $\Delta_p + \Delta_q, 1 < q < p < +\infty$. The reaction terms $f : \Omega \times (0,+\infty) \to (0,+\infty)$ and $g : \Omega \times \mathbb{R}^N \to (0,+\infty)$ are Carathéodory functions obeying suitable growth conditions. Problem (P) possesses three features of interest:

- the operator $u \mapsto \operatorname{div} a(\nabla u)$ can be non-homogeneous;
- the reaction term f is singular (i.e., it behaves like $u^{-\gamma}$ with $\gamma \in (0,1)$) and $f(x,\cdot)$ can be non-monotone;
- the reaction term g is convective (i.e., it depends on ∇u).

These features lead to several challenging issues: (i) non-homogeneity of the elliptic part of the differential operator prevents to exploit standard procedures in the construction of sub-solutions, even when the time is fixed; (ii) due to the presence of a non-monotone singular term, uniform estimates in time are harder to get; (iii) convection terms destroy the variational structure of the elliptic problem associated via semi-discretization in time.
The arguments employed to face all these issues are chiefly based on implicit-explicit semidiscretization (in time), sub-solution and truncation techniques, a-priori estimates, nonlinear regularity theory, and monotonicity. Generalizations to wider classes of operators and reaction terms will be highlighted.
This is work in progress with Simone Ciani.

2.5. **Julia Hauser, TU Dresden.**

A Convergent Finite Volume Method for a Kinetic Model for Interacting Species.
We propose an upwind finite volume method for a system of two kinetic equations. These are formally obtained as the mean-field limit of a second-order system of two nonlocally interacting species. Models of this kind are encountered in a myriad of applications and are typically used to describe large systems of indistinguishable agents such as cell, birds, fish, sheep, ... The associated first-order systems are known to exhibit a range of interesting behaviours such as the formation of swarms.
In this talk, we propose a finite volume scheme for such a model. The discretization is chosen to preserve mass, positivity and the conservation of convex functionals of the solutions. Taking advantage of these properties we show convergence of the scheme. Under additional regularity assumptions, we are able to provide explicit error estimates. Finally, we present simulations showcasing the behaviour of the system numerically.
This is joint work with Valeria Iorio and Markus Schmidtchen.

2.6. **Georg Heinze, TU Chemnitz.**

Nonlocal Cross-Interaction Systems on Graphs: Nonquadratic Finslerian Structure and Nonlinear Mobilities.
In this talk, the evolution of a system of two species with nonlinear mobility on a graph with nonlocal interactions is discussed. We provide a rigorous interpretation of the interaction system as a gradient flow in a Finslerian setting. This not only extends the recent results of Esposito et. al. (2021) to systems of interacting species, but also translates the theory of gradient flows with concave, nonlinear mobilities to this setting. Weakening the notion of Minkowski norm and nonlocal gradient, in the spirit of Agueh (2011), the geometric interpretations and the analysis are carried over to p-Wasserstein-like distances.

2.7. **Sebastian Hensel, HCM Bonn.**

Robustness of the relative entropy approach to interface evolution: Mean curvature flow with constant contact angle.
We consider the mean curvature flow (MCF) of an interface which is allowed to intersect the boundary of a physical domain at a constant contact angle $\alpha \in (0, \pi)$. Formal asymptotic expansions (see Owen and Sternberg, Proc. R. Soc. Lond. A 437, 1992) suggest that this evolution problem arises as the sharp interface limit of the Allen-Cahn equation supplemented by a boundary contact energy contribution. However, rigorous results establishing this connection for $\alpha \neq \pi/2$ are scarce and, in fact, limited to the recent work of Abels and Moser (SIAM J. Math. Anal. 54, 2022), who can only treat a perturbative regime of contact angles close to ninety degrees. I will present a series of new results which yield a rather satisfactory theory for the problem of MCF with constant contact angle and its approximation by the Allen-Cahn equation. In particular, these results apply without any restriction on the value of the contact angle and are given as follows:

- i) We establish (conditional and subsequential) global-in-time convergence of solutions of the Allen-Cahn equation with boundary contact energy towards a concept of BV solutions of MCF with constant contact angle.
- ii) These BV solutions satisfy a sharp weak-strong uniqueness principle up to the first topology change.
- iii) We derive convergence rates for solutions of the Allen-Cahn equation with boundary contact energy and well-prepared initial data up to the first topology change.

The proofs are of variational nature and are based on a novel relative entropy technique which throughout recent years was used to establish such results in the context of various curvature driven interface evolution problems. I will review this method and highlight how the gradient flow structures of the above problems enter in this process.
References

1 S. Hensel, and T. Laux, *BV solutions for mean curvature flow with constant contact angle: Allen-Cahn approximation and weak-strong uniqueness*, arXiv preprint: 2112.11150 (2021).

2 S. Hensel, and M. Moser, *Convergence rates for the Allen-Cahn equation with boundary contact energy: The non-perturbative regime*, arXiv preprint: 2112.11173 (2021).

2.8. **Alexandra Holzinger, TU Vienna.**

Rigorous mean-field derivation of cross-diffusion models of SKT-type.
Cross-diffusion population models, like the SKT model by Shigesada-Kawasaki-Teramoto, play an important role in the study of population dynamics. However, a rigorous derivation starting from a stochastic many-particle system was still missing in the literature. In this talk, I will show how the approach of moderately interacting particles can be used in order to derive cross-diffusion models of SKT-type starting from a stochastic interacting many-particle system. As a byproduct of the mean-field derivation, we also study non-local versions of the underlying PDE models. These non-local PDEs represent an intermediate level between the particle dynamics and the final cross-diffusion partial differential equation. This talk is based on the joint work with Li Chen, Esther Daus and Ansgar Jüngel 'Rigorous derivation of population cross-diffusion systems from moderately interacting particle systems', Journal of Nonlinear Science, 31(6), 1-38 (2021).

2.9. **Anastasiia Hraivoronska, TU Eindhoven.**

Diffusive limit of random walks on tessellations via generalized gradient flows.
In this talk, we present a discrete-to-continuum limit of reversible random walks on tessellations via a variational approach. The approach relies on the so-called 'cosh' generalized-gradient-flow formulation of the corresponding forward Kolmogorov equation. We establish sufficient conditions on sequences of tessellations and jump intensities under which a sequence of random walks converges to a diffusion process with a possibly spatially-dependent diffusion tensor.

2.10. **Kamal Khalil, LMAH Lab Le Havre University of Normandie.**

Analysis of a spatio-temporal advection-diffusion model for human behaviors in a disaster situation.
In this work, we introduce a spatio-temporal mathematical model, with diffusion and advection, describing the evolution of various human behaviors (alert, panic and control behaviors) for a population in a catastrophic event using the theory of first-order macroscopic models. This model consists of an advection-diffusion-reaction coupled system with nonlinear advection and nonlinear boundary conditions. Using semigroup theory of bounded linear operators, we prove the well-posedness, the positivity and the boundedness of the solution of this model. Finally, we present several numerical simulations using different scenarios of evacuation in order to investigate the spatio-temporal behavioral dynamics of a population in a catastrophic event.
This is a joint work with Valentina Lanza, David Manceau & M-A. Aziz-Alaoui at the LMAH of the university of Le Havre.

2.11. **Patrik Knopf, University of Regensburg.**

Two-phase flows with bulk-surface interaction: A Navier–Stokes–Cahn–Hilliard model with dynamic boundary conditions.
We derive a novel thermodynamically consistent Navier–Stokes–Cahn–Hilliard system with dynamic boundary conditions. This model describes the motion of viscous incompressible binary fluids with different densities. In contrast to previous models in the literature, our new model allows for surface diffusion, a variable contact angle between the diffuse interface and the boundary, and mass transfer between bulk and surface. In particular, this transfer of material is subject to a mass conservation law including both a bulk and a surface contribution. The derivation is carried out by means of local energy dissipation laws and the Lagrange multiplier approach. Next, in the case of fluids with matched densities, we show the existence of global weak solutions in two and three dimensions as well as the uniqueness of weak solutions in two dimensions.

2.12. **Chun Yin Lam, WWU Münster.**

Variational convergence of exchange-driven growth model in hydrodynamic limit.
We consider the hydrodynamic limit of mean-field stochastic particle systems on a complete graph. The evolution of occupation number at each vertex is driven by particle exchange with its rate depending on the population of the starting vertex and the destination vertex. In particular, models having condensation phenomena, like the zero-range process, are included. Under a detailed balance condition, the evolution of the law of the particle density and particle flux prescribing the time evolution can be seen as a gradient system in the framework of generalized gradient flows. To pass to the limit in the equation, we use a variational formulation of continuity equation. The associated Energy-Dissipation (ED) functional can be viewed as the rate function of the large deviation principle of the Markov process in the hydrodynamic limit. Towards establishing the convergence of the system in this variational sense, we showed the compactness of the density and flux in the continuity equation when the functional is uniformly bounded, the convergence to a limiting continuity equation and the Γ-convergence of the energy of the gradient system. This is a joint work with André Schlichting.

2.13. **Demou Luo, University of Mannheim.**

Nonconstant steady states and pattern formation of generalized 1D cross-diffusion systems with prey-taxis.
Cross-diffusion effects and tactic interactions are the processes that preys move away from the highest density of predators preferentially, or vice versa. It is renowned that these effects have act some significant roles in ecology and biology, which are also essential to the maintenance of diversity of species. To simulate the stability of systems and illustrate their spatial distributions, we consider positive nonconstant steady states of a generalized cross-diffusion model with prey-taxis and general functional responses in one dimension. By applying linear stability theory, we analyse the stability of the interior equilibrium and show that even when the cross-diffusion rate d is negative, the corresponding cross-diffusion model has opportunity to achieve its stability. In addition,

we obtain the practical significance of $d < 0$. Meanwhile, in addition to the cross-diffusion effect, tactic interaction can also destabilize the homogeneity of predator-prey system if the tactic interaction coefficient $\chi < 0$. Otherwise, taxis effect can stabilize the homogeneity. Furthermore, the existence and stability of positive nonconstant steady states of systems have been proved by strict analysis, and we also offer elaborate illustration and exact computations to ensure some characters, for instance, rotational direction and pitchfork bifurcation of local branches.

2.14. **Annamaria Massimini, TU Vienna.**

Analysis of a Poisson-Nernst-Planck-Fermi model for ion transport in biological channels.
This work studies a Poisson-Nernst-Planck-Fermi theory to describe the evolution of a mixture of ions through biological membranes or nanopores. In the model, the ion concentrations solve a cross-diffusion system in a bounded domain with mixed Dirichlet-Neumann boundary conditions. A drift term due to the electric potential is also present in the equations. Such potential is coupled to the concentrations through a Poisson-Fermi equation.
The novelty and the advantage of this model - with respect to the one studied in - is to take into account ion-ion correlations, which is crucial in the case of strong electrostatic coupling and high ion concentrations.
The global-in-time existence of bounded weak solutions is shown, by using the boundedness-by-entropy method, extended to nonhomogeneous boundary conditions. Moreover, some simulations are illustrated and discussed.

2.15. **Salem Nafiri, Casablanca.**

Homogenization of weakly coupled thermoelastic wave model.
The aim of this work is twofold. Firstly, we present a novel method for studying the asymptotic behaviour of the solutions of a weakly coupled thermoelastic wave model. Secondly, we study the homogenization problem.

2.16. **Alex Rossi, FAU Erlangen.**

Analysis of kinetic models for label switching and stochastic gradient descent.
We provide a novel approach to the analysis of kinetic models for label switching, which are used for particle systems that can randomly switch between gradient flows in different energy landscapes. Besides problems in biology and physics, we also demonstrate that stochastic gradient descent, the most popular technique in machine learning, can be understood in this setting, when considering a time-continuous variant. Our analysis is focusing on the case of evolution in a collection of external potentials, for which we provide analytical and also some numerical results about the evolution as well as the stationary problem. We consider moreover effects of limits of the parameters and mean field limits, with the introduction of a nonlinear version of the model. This talk is a joint work with Martin Burger.

2.17. **Sebastian Throm, Umeå University.**

Self-similar long-time behaviour for 1d kinetic equations.
We consider the question of self-similar long-time behaviour for one-dimensional kinetic equations. Our approach relies on perturbation arguments from explicitly solvable models and a key tool is the precise analysis of the spectral gap of the linearised collision operator in self-similar variables. In a first step, this result allows to prove the uniqueness of self-similar profiles under a suitable normalisation.