universität wien
Fakultät für Mathematik

VORTRÄGE

Tenure Track „PARTIAL DIFFERENTIAL EQUATIONS IN THE APPLIED SCIENCES"

Montag, 18. März 2019, Seminarraum 05

Matthias Erbar (Universität Bonn)

9:00 Uhr – 9:20 Uhr: Didaktischer Vortrag
„Das Maximumprinzip für den Laplace Operator"

9:50 Uhr – 10:35 Uhr: Wissenschaftlicher Vortrag
„A gradient flow approach to the Boltzmann equation"
In this talk I will present an interpretation of the spatially homogeneous Boltzmann equation as the gradient flow of the entropy. This gradient flow structure relies on a geometry on the space of probability measures that takes the collision process between particles into account. This point of view leads to a new approach to proving propagation of chaos for Kac's random walk and its convergence to the Boltzmann equation.

Dienstag, 19. März 2019, Seminarraum 11

Martin Heida (WIAS Berlin)

9:00 Uhr – 9:20 Uhr: Didaktischer Vortrag
„Weak solutions for gradient flows"
We recall the concept of weak solutions from PDE I and use basics from convex analysis to motivate the concept of weak solution to gradient flows.

9:50 Uhr – 10:35 Uhr: Wissenschaftlicher Vortrag
„The SQRA Operator: Convergence Behaviour and Applications"
The Squareroot Approximation Operator (SQRA) is a numerical FV-operator that has recently been derived by M. Weber and coworkers and has the form of a discrete spatial chemical master equation. We use methods from stochastic homogenization to prove convergence in the context of high dimensional numerical implementation. We furthermore show that the SQRA is equivalent with the Scharfetter-Gummel scheme and use this insight to prove convergence of order 1 of both schemes in low dimensional settings. This is particularly possible due to a deep connection between the SQRA and the gradient structure of the Fokker-Planck equation discussed by Jordan, Kinderlehrer and Otto. We finally discuss physical implications of our insights and possible future applications to hydrodynamic limits arising in the modelling of organic semiconductors.

Mittwoch, 20. März 2019, Seminarraum 05

Marie-Therese Wolfram (University of Warwick)

9:00 Uhr – 9:20 Uhr: Didaktischer Vortrag
„The linear transport equation and scalar conservation laws“

9:50 Uhr – 10:35 Uhr: Wissenschaftlicher Vortrag
„On cross-diffusion systems and asymptotic gradient flows“

Cross-diffusion systems arise naturally to describe the dynamics of multiple interacting species in the life and social sciences. Such systems can be formally derived from a simple exclusion process on a lattice or a stochastic differential equation system using for example the method of matched asymptotics. Often the underlying microscopic gradient flow structure is lost in the limit. Hence we introduce the concept of asymptotic gradient flows and discuss how it can be used to study the behavior close to equilibrium. Next we focus on segregation phenomena, which can often be observed in cross-diffusion systems. We discuss the analysis and the segregation process in the case of two models for pedestrian and population dynamics, and illustrate our results with numerical simulations.

Donnerstag, 21. März 2019, Hörsaal 05

Dietmar Ölz (The University of Queensland)

9:00 Uhr – 9:20 Uhr: Didaktischer Vortrag
„1D conservation laws - traffic modelling“

9:50 Uhr – 10:35 Uhr: Wissenschaftlicher Vortrag
„Cells and tissues as active matters - modelling and mathematical analysis“

Shape and active motion of biological cells are closely linked to active force generation and remodelling of their cytoskeletons. In collective cell migration and tissue-level morphogenesis the cytoskeletons of adjacent cells are coupled both, mechanically and by mechanochemical feedback. In this talk I will explore approaches to model, simulate and analyze these phenomena starting with particle based models. I use them as the basis for the derivation of fluid-type continuum models amenable to mathematical analysis.
In the first part of the talk I will introduce a particle model for cell division rings and derive a fluid type continuum model to gain insight into its predictions. In the second part of the talk I introduce a 1D model for collective cell migration in an epithelial sheet. Its travelling wave analysis can be made explicit predicting a polarization wave and associated wave speed which we could ultimately observe in experiments.

Donnerstag, 21. März 2019, Seminarraum 01

Angelika Manhart (Imperial College London)

15:00 Uhr – 15:20 Uhr: Didaktischer Vortrag

„Adding diffusion to logistic growth: Travelling waves in the Fisher-KPP equation“

We start with the space independent model for the logistic (=saturated) growth of a species. Allowing the species to move by diffusion turns the ordinary differential equation (ODE) into a partial differential equation (PDE). This equation is the famous Fisher-KPP equation which has been used for modelling population dynamics, gene spread and flame propagation. I'll discuss how to show the existence of travelling wave solutions using phase-plane analysis.

15:50 Uhr – 16:35 Uhr: Wissenschaftlicher Vortrag

„Cell movement on different scales: Using PDEs to explain biology“

Partial differential equation (PDE) models can be a powerful tool for understanding emerging patterns in the life sciences. To mathematically capture these structures, one of the biggest challenges to overcome is the problem of scales: small scale events can result in large scale effects. I will present two projects, which exemplify the synergistic effects of applied mathematics and biology.

In the first part of the talk I will focus on a structure that lies at the heart of many types of cell movement: dynamic networks of branched actin fibres. Using experimental data to inform the models, we investigate how cofilin, a known disassembly agent, creates dynamic networks of fixed lengths. To capture the observed macroscopic fragmentation of the network, we combine PDE-based modelling of the cofilin binding dynamics with a discrete network disassembly model. This allows to predict the equilibrium network length across various control parameters.

In the second part I will discuss modelling, simulation and analysis of travelling waves in collectively moving bacterial swarms. The macroscopic PDEs describing the bacteria are derived from an individual-based description using a biology-focused coarse-graining method. Using the continuous model we can further investigate the unusual phenomena of counter-propagating travelling waves: Two families of interacting travelling waves whose profiles remain unchanged, but whose composition is modified by the oncoming wave.

Freitag, 22. März 2019, Hörsaal 08

Sabine Hittmeier (Universität Wien)

9:00 Uhr – 9:20 Uhr: Didaktischer Vortrag

„Waves in Reaction-Diffusion-Equations“

Reaction-diffusion equations have a wide range of applications in particular in biology and chemistry and are well known for their ability to reveal patterns and waves. The appearance of a wave in many phenomena is a key element to a development process and a profound understanding of their properties is therefore essential. A classical nonlinear reaction-diffusion equation is the so-called Fisher equation, for which travelling wave solutions connecting two different far-field states are investigated. Their existence proof thereby is based upon phase plane analysis.

9:50 Uhr – 10:35 Uhr: Wissenschaftlicher Vortrag

„Multiscale asymptotics and analysis of moist atmospheric flows“

Model reductions in meteorology by scale analysis are inevitable and therefore have a long history. The key technique for a systematic study of complex processes involving the interaction of phenomena on different length and time scales is multiple scales asymptotics. Due to their major contribution to the energy transport of particular interest are hot towers, which are large cumulonimbus clouds that live on small horizontal scales. In comparison to existing studies we in joint work with R. Klein not only incorporate moisture into the model via balance equations for water vapor, cloud water and rain, but also refine the thermodynamics by taking into account the different gas constants and heat capacities for water in contrast to dry air. This refined setting is demonstrated to be essential by leading to different force balances. These deep convective clouds furthermore constitute the building blocks of larger scale convective storms.

Incorporating the setting of organised convection into the multiscale approach requires the introduction of systematic averaging procedures, allowing in particular to quantify the modulation of the larger scale flow by the moisture processes in the cloud regions.
While the just described multiscale asymptotics are purely formal, also results from joint work with R. Klein, J. Li and E. Titi on the rigorous analysis of the atmospheric flow models with moisture and phase transitions are presented. The global existence and uniqueness of solutions for the moisture model building the basis for the above expansions will be demonstrated, where at first the flow field is assumed to be given. The moisture dynamics are then further coupled to the primitive equations, which result from the full viscous compressible governing equations by making only one simplification, namely the assumption of hydrostatic balance. These primitive equations have been demonstrated to serve in general as a good approximation for the flow field and thus build the basis for weather forecast and climate models. A rigorous analysis for this set of equations is therefore of particular interest not only from a mathematical point of view.

Freitag, 22. März 2019, Hörsaal 17

Jan Haskovec
(King Abudullah University of Schience and Technology)

15:00 Uhr – 15:20 Uhr: Didaktischer Vortrag

„Turing instability and pattern formation in reaction-diffusion systems“

In 1952 Alan Turing suggested that under certain conditions chemicals can react and diffuse to produce heterogeneous spatial patterns. The most surprising aspect of the Turing mechanism is that diffusion in a reacting chemical system can actually have a destabilizing influence. In this talk I shall introduce the mathematical theory of this phenomenon and demonstrate how a spatially homogeneous and linearly stable steady state of a binary reaction system can be destabilized by introducing diffusion with sufficiently different diffusivities for the two chemicals

15:50 Uhr – 16:35 Uhr: Wissenschaftlicher Vortrag

„Cockroach aggregates, flocks of birds, leaf venation: pattern formation in diffusive and kinetic partial differential equation models“

I shall present models of mathematical biology describing the emergence of nontrivial patterns via collective actions of many individual entities: aggregating cockroaches, flocking birds and self-organizing phenomena in biological transportation networks. In the limits of large populations (mean field limits), they are modeled by systems of diffusive or kinetic partial differential equations. I shall demonstrate how our understanding of pattern emergence is supported by a variety of analytical methods: Lyapunov functional and stability estimates for (delay) differential equations, Ito calculus methods for systems with noise, energy dissipation and asymptotic stability methods for reaction-diffusion equations.
