Schedule

Workshop on "Applied PDEs and kinetic equations: from physics to life sciences and beyond"

Wolfgang Pauli Institute, Vienna
18th – 20th April 2018

Organizers: Marie Doumic (WPI & INRIA)
Jan Haskovec (KAUST)
Marie-Therese Wolfram (Warwick & RICAM Linz)
Klemens Fellner (KFU Graz)
Lukas Neumann (U. Innsbruck)

Wednesday 18th

14:00 - 14:45	Uri Ascher, U. British Columbia *"Numerical Methods in Visual Computing: what we can learn from each other"*
14:50 – 15:35	Jorge Zubelli, IMPIA *"A Non-intrusive Stratified Resampler for Regression Monte Carlo with Applications to Reaction-Diffusion Equations."*
15:40 – 16:10	Coffee break
16:15 – 16:55	Colloquium talk with Martin Burger *"Propagation of gradient flow structures from microscopic to macroscopic models"*
17:00 – 17:45	Colloquium and reception

Thursday 19th

9:15 – 10:00	Vincent Calvez, ENS Lyon
	"Equilibria in quantitative genetic model"
10:05 – 10:50	Anne Nouri, U. Marseille
	"Bose condensates in interaction with excitations. Two-component space-dependent models close to equilibrium"
10:55 – 11:25	*Coffee break*
11:25 – 12:10	Ingenuin Gasser, U. Hamburg
	"A few examples of alternative energy power stations: modelling, simulation and optimisation"
12:15 – 14:00	*Lunch*
14:00 – 14:45	J. Victor Small
	"Moving cells and pathogens with actin: from structure to mathematical models"
14:50 – 15:35	Dietmar Oelz, U. Queensland
	"Microtubule dynamics, kinesin-1 sliding and dynein action drive growth of cell processes"
15:40 – 16:10	Coffee break
16:10 – 16:55	Angelika Manhart (NYU Courant)
	"Traveling Waves in Cell Populations"
17:00 – 17:45	Marie Doumic (INRIA c/o U. Wien & KAUST)
	"Some entropy-based results for linear and non-linear aggregation-fragmentation equations"

Friday 20th

9:15 – 10:00	Clement Mouhot, U. Cambridge
	"De Giorgi-Nash-Moser and H\"ormander theories: new interplays"
10:05 – 10:50	Gael Raoul, X Palaiseau
	"Wasserstein estimates and macroscopic limits in a model from ecology"
10:55 – 11:25	*Coffee break*
11:25 – 12:10	Carlotta Cuesta, U. Basque Country
	"Some aspects of a non-local regularisation of scalar conservation laws"
12:15 – 14:00	*Lunch*
14:00 – 14:45	Emeric Bouin, U. Paris-Dauphine
	"Hypocoercivity without confinement"
14:50 – 15:35	Peter Markowich (WPI c/o U. Wien & KAUST)
	"Discrete and continuum modeling of biological network formation"
15:40 – 16:00	Final Remarks

Workshop on "Applied PDEs and kinetic equations: from physics to life sciences and beyond"

Wed, 18. April - Fr, 20. April 2018

Organizers: Marie Doumic (WPI & INRIA)
Jan Haskovec (KAUST)
Marie-Therese Wolfram (Warwick & RICAM Linz)
Klemens Fellner (KFU Graz)
Lukas Neumann (U. Innsbruck)

Abstracts

Uri Ascher (U. British Columbia)

Title: Numerical Methods in Visual Computing: what we can learn from each other

Abstract: Visual computing is a wide area that includes computer graphics and image processing, where the "eyeball-norm" rules. I will briefly discuss two case studies involving numerical methods and analysis applied to this area. The first case study involves motion simulation and calibration of soft objects such as plants, skin, and cloth. The governing elastodynamics PDE system, discretized in space already at the variational level using co-rotated FEM, leads to a large, expensive to assemble, dynamical system in time, where the damped motion may mask highly oscillatory stiff-ness. An exponential differencing method will be described, in search for more quantitative computations. The second case study involves some image processing problems where there is a premium for local approaches that do not necessarily use underlying PDEs. I will demonstrate and discuss.

Jorge Zubelli (IMPIA)

Title: A Non-intrusive Stratified Resampler for Regression Monte Carlo with Applications to Reaction-Diffusion Equations

Abstract: Stochastic dynamic programming equations are classic equations arising in the resolution of nonlinear evolution equations, like in stochastic control. In this talk we address a technique to solve certain dynamic programming equations associated to a given Markov chain X, using a regression-based Monte Carlo algorithm. More specifically, we assume that the model for X is not known in full detail and only a root sample $X^1,\dots,X^M$ of such process is available. By a stratification of the space and a suitable choice of a probability measure, we design a new resampling scheme that allows to compute local regressions (on basis functions) in each stratum. The combination of the stratification and the resampling allows to compute the solution to the dynamic programming equation (possibly in large dimension) using only a relatively small set of root paths. To assess the accuracy of the algorithm, we establish non-asymptotic error estimates in L2 of the chosen measure. Our numerical experiments illustrate the good performance, even with as low as 20 to 40 root paths. This talk is based on joint work with Emmanuel Gobet and Gang Liu (E. Polytechnique, Paris) published in SIAM J. Numer. Anal., 56(1), 50?77. 2018.

Vincent Calvez (ENS Lyon)

Title: Equilibria in quantitative genetic models

Abstract: I will describe recent results obtained in the asymptotic analysis of quantitative genetic models. I will focus on the adaptation of a population to a moving fitness optimum. Our methodology is able to handle age-structured populations, either reproducing in an asexual way or with a sexual mode of reproduction (namely Fisher's infinitesimal model).

Anne Nouri (U. Marseille)

Title: Bose condensates in interaction with excitations. Two-component space-dependent models close to equilibrium

Abstract: We consider models for Bose gases in the so-called 'high-temperature range' below the temperature where Bose-Einstein condensation sets in. The first model is of non-linear two-component type and vanishing force term, consisting of a kinetic equation with periodic boundary conditions for the distribution function of a gas of excitations interacting with a Bose condensate, which is described by the Gross-Pitaevskii equation. Results on well-posedness and long time behavior are proved in a Sobolev space setting close to equilibrium. The second model has a non-vanishing force term and is linearized around a space-homogenous equilibrium.

Ingenuin Gasser (U. Hamburg)

Title: A few examples of alternative energy power stations: modelling, simulation and optimisation

Abstract: We discuss power stations based on solar thermal energy, on condensation and on pressure retarded osmosis. In all cases we aim to consider the complete power station and to optimize the net power output. This is done with respect to system parameters and also in the operational phase. Mathematically this relies on fluid dynamical models with a special emphasis on energy, its production mechanisms and the related energy losses.

J. Victor Small (U. XY)

Title: Moving cells and pathogens with actin: from structure to mathematical models

Abstract: Cell movement plays an essential role in diverse processes, not least during embryonic development and wound repair. Armies of mobile immune cells are likewise engaged in the defence of the body against invading pathogens. Cell movement has been a popular playground for mathematicians and there has been no shortage of theoretical models of how cells extend a thin sheet, a so-called “lamellipodium” at the cell front to initiate migration. Our recent application of electron tomography in studies of migrating cells provided the first complete structure of the branched actin networks that make up lamellipodia. These findings coincided with the timely collaboration with the group of Christian Schmeiser and the subsequent development of a realistic mathematical simulation of the actin-mediated protrusion process. Actin-based protrusion is also used by certain viruses, which usurp the motile machinery of cells to spread their infection. These viruses move in cells by generating a comet tail of actin at their rear. Using again electron tomography we were able to determine, for the first time, the structural organization of actin comet tails. This structural information was then utilized in collaboration with the Schmeiser group to develop a new, more realistic mathematical model of pathogen propulsion. In conclusion, the fortuitous and timely interest of Christian Schmeiser in the cytoskeleton resulted in a productive and fruitful, inter-disciplinary collaboration.

Dietmar Oelz (U. Queensland)

Title: Microtubule dynamics, kinesin-1 sliding and dynein action drive growth of cell processes

Abstract: Intracellular transport is driven by molecular motors which pull cargo vesicles along cytoskeletal filaments. In a collaborative study combining experiments and Brownian Dynamics simulations we investigate cellular morphogenesis of neuron cells, namely establishment and growth of axons and dendrites, which is both driven by kinesin and dynein motors. We find that the growth of cellular processes depends critically on dynamical instability, i.e. alternating growing and shrinking, of microtubule fibres.

Angelika Manhart (NYU Courant)

Title: Traveling Waves in Cell Populations

Abstract: Transport-reaction equations are abundant in the description of movement of motile organisms. In this talk I will focus on a system of coupled transport-reaction equations that arises from an age-structuring of a species of turning individuals. The highlight consists of the explicit construction and characterization of counter-propagating traveling waves, patterns which have been observed in bacterial colonies, e.g. in earth-dwelling myxobacteria. Fascinatingly, while the wave profiles do not change, the wave composition does and the fractions of reversible and non-reversible bacteria form waves traveling in the opposite direction. Stability analysis reveals conditions for wave formation as well as for pulsating-in-time spatially constant solutions.

Marie Doumic (INRIA c/o U. Wien & KAUST)

Title: Some entropy-based results for linear and non-linear aggregation-fragmentation equations

Abtract: Entropy-based methods, and in particular the so-called "generalised relative entropy" inequalities, have been developed and successfully applied to structured population equations, and in particular to aggregation-fragmentation problems, over the last two decades. In this talk, we study how entropy methods have been recently extended to measure solutions [1] as well as to the convergence towards a periodic limit [2]. We also investigate the long-time dynamics of a family of nonlinear nucleation-aggregation equations, for which specific entropy functionals may be built [3]. Ref: [1] Thomasz Debiec, Marie Doumic, Piotr Gwizada, Emil Wiedemann, Relative entropy method for measure solutions of a structured population model, 2018 [2] Etienne Bernard, Marie Doumic, Pierre Gabriel, Cyclic asymptotic behaviour of a population reproducing by fission into two equal parts, 2016 [3] Juan Calvo, Marie Doumic, Benot Perthame, Long-time asymptotics for polymerization models, 2017

Clement Mouhot (U. Cambridge)

Title: De Giorgi-Nash-Moser and H\"ormander theories: new interplays

Abstract: We report on recent results and a new line of research at the crossroad of two major theories in the analysis of partial differential equations: the tools developed for studying elliptic or parabolic equations with rough coefficients on the one hand (De Giorgi, Nash, Moser, Krylov, Safonov), and the theory of hypoellipticity (H\"ormander) on the other hand. We discuss recent results about hypoelliptic equations of kinetic type with rough coefficients. We then discuss applications to the Boltzmann and Landau equations and present a program of research about the regularity for these equations, with some open questions.

Gael Raoul (X Palaiseau)

Title: Wasserstein estimates and macroscopic limits in a model from ecology

Abstract: We are interested in evolutionary biology models for sexual populations. The sexual reproductions are modelled through the so-called Infinitesimal Model, which is similar to an inelastic Boltzmann operator. This kinetic operator is then combined to selection and spatial dispersion operators. In this talk, we will show how the Wasserstein estimates that appear naturally for the kinetic operator can be combined to estimates on the other operators to study the qualitative properties of the solutions. In particular, this approach allows us to recover a well-known (in populations genetics) macroscopic model.

Carlotta Cuesta (U. Basque Country)

Title: Some aspects of a non-local regularization of scalar conservation laws

Abstract: We consider a regularisation of a scalar conservation law where the viscous term is a Caputo type fractional derivative of order between 1 and 2. We shall first focus on some recent results on the study travelling wave solutions of the Korteweg-de Vries-Burgers equation with such non-local viscous term, the third order one being local and linear. This model equation arises in the analysis of a shallow water flow by performing formal asymptotic expansions associated to the triple-deck regularisation (which is an extension of classical boundary layer theory). We show rigorously the existence of these waves in the case of a genuinely non-linear flux and for the case of a non genuinely non-linear one, we give results on the existence of the waves that do not satisfy the entropy condition. We shall also discuss the vanishing viscosity limit when the third order term is not present.

Emeric Bouin (U. Paris-Dauphine)

Title: Hypocoercivity without confinement

Abtract: In this talk, we will present some recent results on decay to zero for linear kinetic models with weak or without space confinement. Joint with Mouhot, Mischler, Dolbeault, Schmeiser.

Peter Markowich (WPI c/o U. Wien & KAUST)

Title: Discrete and continuum modeling of biological network formation

Abstract: Motivated by recent papers describing rules for natural network formation in discrete settings, we propose an elliptic-parabolic system of partial differential equations. The model describes the pressure field due to Darcy's type equation and the dynamics of the conductance network under pressure force effects with a diffusion rate representing randomness in the material structure. After a short overview of the principles of discrete network modeling, we show how to derive the corresponding macroscopic (continuum) description. The highly unusual structure of the resulting PDE system induces several interesting challenges for its mathematical analysis. We give a short overview of the tools and tricks that can be used to overcome them. In particular, we present results regarding the existence of weak solutions of the system, based on recent results on elliptic regularity theory. Moreover, we study the structure and stability properties of steady states that play a central role to understand the pattern capacity of the system. We present results of systematic numerical simulations of the system that provide further insights into the properties of the network-type solutions.