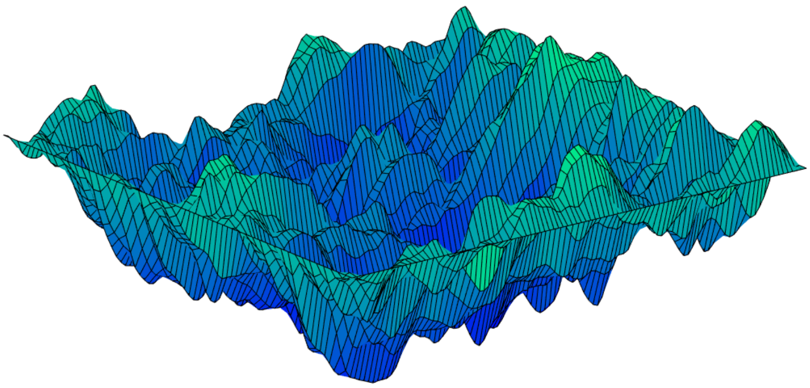
Workshop on

Numerics for Stochastic Partial Differential Equations and their Applications

December 12-16, 2016



as part of the
Radon Special Semester 2016 on

Computational Methods in Science and Engineering

ÖAW ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN

RICAM JOHANN·RADON·INSTITUTE FOR COMPUTATIONAL AND APPLIED MATHEMATICS

Partial Differential Equations are used to model real world systems. However for a system subjected to perturbation too complex to be described by deterministic perturbations, Stochastic Partial Differential Equations have proved to be most useful. Environmental loadings such as wind, storms, and earthquake are non-reproducible phenomena, which can be described successfully by stochastic processes.
Another example is provided by the Stochastic Navier-Stokes equations which are used in particular to model the airflow around a wing perturbed by the random state of the atmosphere and weather. Developments in such turbulence models lead to questions about drag reduction and lift enhancement in aircraft, noise control and combustion control. The spread of epidemics in some regions and the spatial spread of infectious diseases can be realistically modelled and mathematically described as a travelling front propagation of a stochastic nonlinear parabolic KPP equation. Investigating realistic epidemic models leads to understanding the development of illnesses like SARS, Ebola and bird flu, and in turn results in new strategies in combating such major diseases. SPDEs are also used in physical sciences (e.g. in turbulence of plasma, physics of growth phenomena such as molecular beam epitaxy and fluid flow in porous media with applications to the production of semiconductors and oil industry) and biology (e.g. bacteria growth and DNA structure). Models related to the so called passive scalar equations have potential applications to the understanding of waste (e.g. nuclear) convection under the earths surface.

Workshop Organizers

Erika Hausenblas, Montanuniversität Leoben, Austria
Zdzisław Brzeźniak, University of York, UK
Anne de Bouard, CNRS and Ecole Polytechnique, France

Welcome

to Linz and thank you very much for participating in the sixth *RICAM Special Semester on Computational Methods in Science and Engineering*, hosted by the Johann Radon Insitute for Computational and Applied Mathematics (RICAM) from October 3 to December 16, 2016.

We sincerely hope that you enjoy your stay in Linz!

Local Organizing Committee

Evelyn Buckwar, Johannes Kepler Universität, Austria
Pani W. Fernando, Montanuniversität Leoben, Austria
Tsiry Randrianasolo, Montanuniversität Leoben, Austria

Contents

Information

Workshop Information

Registration. The workshop registration will be on December 12th, 2011 from 8:00 - 8:50 am next to the seminar room SP2 416 on the 4th floor of the Science Park Building 2 (see floor plan). Participants that arrive later in the week can register at the special semester office SP2 456.

Registration Fee. Non-invited participants are kindly asked to pay the registration fee in cash upon registration.

Campus plan and overview map as well as a floor plan of the 4th floor of the workshop venue (Science Park Building 2) are located on the next pages.

Seminar room. The workshop will take place in seminar room SP2 416 on the 4th floor of the Science Park Building 2 (see floor plan).

Program. A time schedule for the workshop is located on the backside of this booklet.

Coffee breaks. The coffee breaks will be in the corridor of the 4th floor of the Science Park Building 2.

Internet access. There will be an extra information sheet regarding internet access available at registration.

Social Events

Welcome Reception & Poster Session. Monday, December 12th, 2011, 5:15 pm, on the 4th floor of the Science Park Building 2.

Conference Dinner. Tuesday, December 13th, 2011, 7:00 pm, at the restaurant "Kepler's", situated in the Mensa building

Drinks & 2nd Poster Session. Thursday, December 15th, 2011, 5:15 pm, on the 4th floor of the Science Park Building 2.

Restaurants and Cafes

- Mensa Markt (lunch time only) - Main canteen of the University (see campus plan)
- KHG Mensa (lunch time only) - Smaller canteen - good traditional food (see overview map: "KHG Linz")
- Pizzeria "Bella Casa" - Italian and Greek restaurant (located next to the tram stop)
- Chinese restaurant "Jadegarten" - (located close by the tram stop, adjacent to "Bella Casa")
- Asia restaurant "A2" - (located behind the Science Park on Altenbergerstrasse)
- "Chat" cafe - coffee, drinks and sandwiches (located in the "Hörsaaltrakt" - see overview map)
- Cafe "Sassi" - coffee, drinks and small snacks (located in the building "Johannes Kepler Universität" - see overview map)
- Bakery "Kandur" - bakery and small cafe (located opposite the tram stop)

General Information

Accommodation. The arranged accomodation for invited participants is the "Sommerhaus" hotel. You can find its location in the overview map on page 4.

Special Semester Office: Room SP2 456. The special semester administrator is Susanne Dujardin.

Audiovisual & Computer Support. Room SP2 458, Wolfgang Forsthuber or Florian Tischler.

Orientation/ Local Transport. From the railway station you have to take tram number 1 or 2 in direction “Universität”. It takes about 25 minutes to reach the desired end stop “Universität”.

In order to get to the city center of Linz (“Hauptplatz”) and back you have to take again tram number 1 or 2 (about 20 minutes). For more information see `www.ricam.oeaw.ac.at/location/`.

Taxi Numbers.

+43 732 6969	Oberösterreichische Taxigenossenschaft
+43 732 2244	2244 Linzer Taxi
+43 732 781463	Enzendorfer Taxi & Transport
+43 732 2214	Linzer Taxi
+43 732 660217	LINTAX TaxibetriebsgesmbH

Further important phone numbers.

+43 (0)732 2468 5222	RICAM & Special Semester Office (Susanne Dujardin)
+43 (0)732 2468 5250/5255	RICAM IT Support (Florian Tischler/ Wolfgang Forsthuber)
+43 (0)732 2457-0	Reception of Hotel Sommerhaus
133	General emergency number for the police
144	General emergency number for the ambulance

More information about RICAM can be found at `www.ricam.oeaw.ac.at`. See also the Special Semester webpage `www.ricam.oeaw.ac.at/specsem/specsem2011/` for additional information.

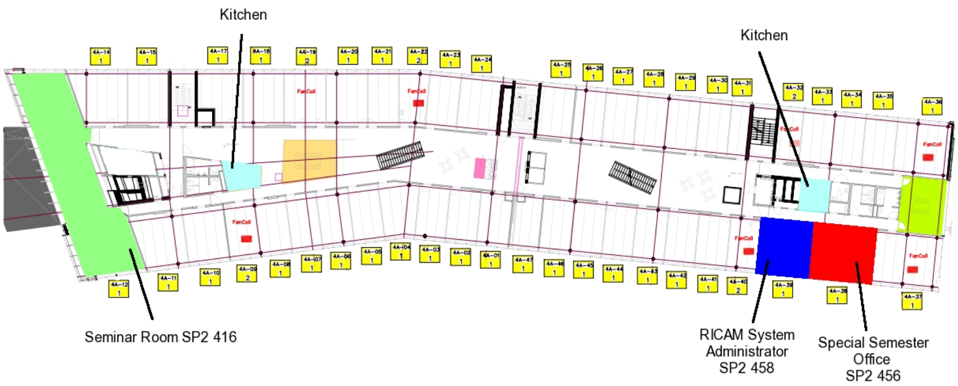


Figure 1: 4th floor of Science Park Building 2.

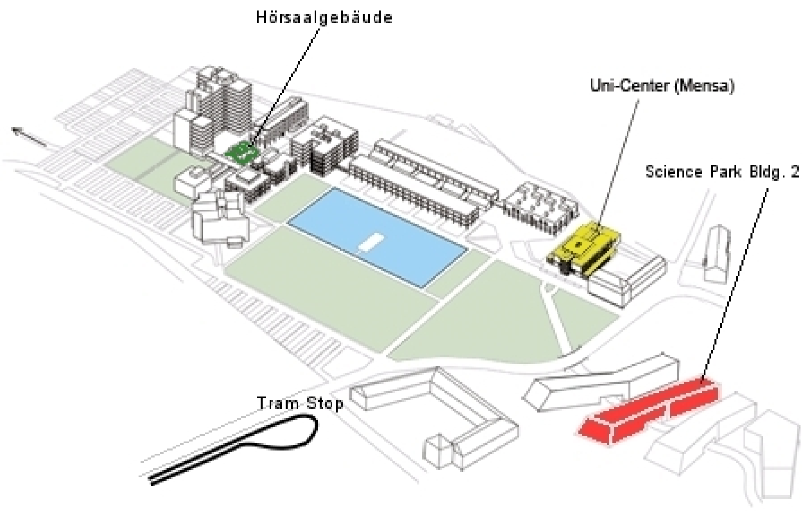


Figure 2: Campus plan

Figure 3: Overview map

Program

Monday, December 12th

08:00 - 08:50	Registration
08:50 - 09:00	Opening
09:00 - 09:50	Nizar Touzi (Centre de Mathématiques Appliquées Ecole Polytechnique, France) "*Branching particles representation for nonlinear PDEs*"
09:50 - 10:40	Dan Crisan (Imperial College, London) "*Particle representations for SPDEs with boundary conditions*"
10:40 - 11:00	Coffee Break
11:00 - 11:50	Arnulf Jentzen (ETH Zurich) "*Numerical approximations for nonlinear stochastic partial differential equations*"
11:50 - 12:40	Francois Alouges (Ecole Normale Superieure de Cachan, France) "*Homogenization of ferromagnetic materials*"
12:40 - 14:30	Lunch Break
14:30 - 15:20	Björn Birnir (Department of Mathematics, University of California at Santa Barbara, USA) "*Rough solutions of the Stochastic Navier-Stokes Equation*"
15:20 - 16:10	Pani W. Fernando (Montanuniversität Leoben, Austria) "*Nonlinear filtering with correlated Lévy noise characterized by copula*"
16:10 -17:00	**Poster Session & Welcome Reception**

Tuesday, December 13th

09:00 - 09:50	Wilhelm Stannat (Technische Universität Berlin, Germany) "*Stochastic Nerve Axon Equations*"
09:50 - 10:40	Mihály Kovács (University of Otago, New Zealand) "*Strong convergence of a fully discrete finite element approximation of the stochastic Cahn-Hilliard equation*"
10:40 - 11:00	Coffee Break
11:00 - 11:50	Andreas Prohl (Eberhard-Karls-Universität Tübingen) "*The Forward Backward stochastic heat equation: numerical analysis and simulation*"
11:50 - 12:40	Josselin Garnier (Ecole Polytechnique, France) "*Effective fractional wave equations in random multiscale media*"
12:40 - 14:30	Lunch Break
14:30 - 15:20	Denis Talay (Inria and Ecole Polytechnique) "*Sensitivity analyses w.r.t. the noise and the coefficients of stochastic differential equations*"
15:20 - 16:10	Knut Solna (University of California at Irvine, USA) "*Beam-wave backscattering in random multiscale media*"
16:10 - 17:00	Ludovic Goudenège (Université Paris-Est, France) "*Numerical simulations of meta stable dynamics in stochastic partial differential equations*"
19:00	**Conference dinner**

Wednesday, December 14th

09:00 - 09:50	Noel Walkington (Carnegie Mellon University, USA) "*Numerical Approximation of Parabolic SPDE's*"
09:50 - 10:40	Imran Biswas (TIFR Centre for Applicable Mathematics, India) "*On the hyperbolic conservation laws with noise: continuous dependence and approximations*"
10:40 - 11:00	Coffee Break
11:00 - 11:50	Istvan Gyöngy (The University of Edinburgh, UK) "*On localisation errors and fully discretised schemes for stochastic PDEs*"
11:50 - 12:40	Paul Razafimadimby (University of Pretoria, South Africa) "*Time discretization of stochastic Langrangian Averaged Euler equations on non-smooth domain*"
12:40 - 14:30	Lunch Break
14:30 - 15:20	Christian Kühn (Technische Universität Wien, Österreich) "*Deterministic Continuation and CERES for Stochastically Forced PDEs*"
15:20	excursion to advent market(please feel free to make use of the seminar room and the Special Semester offices)

Thursday, December 15th

09:00 - 09:50	Charles-Edouard Brehier (Institut Camille Jordan - Université Lyon 1, France) "*Optimal weak convergence rates for discretization of SPDEs with multiplicative noise*"
09:50 - 10:40	Gabriel Lord (Heriot Watt University, UK) "*Adaptive timestepping for S(P)DEs to control growth*"
10:40 - 11:00	Coffee Break
11:00 - 11:50	Julien Vovelle (Université Claude Bernard Lyon 1, France) "*Approximation of stochastic scalar conservation laws by the Finite Volume method*"
11:50 - 12:40	Liu Jie (National University of Singapore, Singapore) "*Order of convergence of splitting schemes for both deterministic and stochastic nonlinear Schrödinger equations*"
12:40 - 14:30	Lunch Break
14:30 - 15:20	Lubomir Banas (Bielefeld University, Germany) "*Numerical approximation of the stochastic Cahn-Hilliard equation near the sharp interface limit*"
15:20 - 16:10	Coffee Break
16:10 - 17:00	Robert Scheichl (University of Bath, UK) "*Multilevel Subset Simulation for Rare Events*"

Friday, December 16th

09:00 - 09:50	Francesco Ragone (University of Milan-Bicocca, Italy) "*Simulation of heat waves in climate models using large deviation algorithms*"
09:50 - 10:40	Li Liang (Montanuniversität Leoben, Austria) "*Weak martingale solutions of stochastic Landau–Lifshitz–Gilbert equation coupled with Maxwell's equation*"
10:40 - 11:00	Coffee Break
11:00 - 11:50	Utpal Manna (Indian Institute of Science Education and Research Thiruvananthapuram, India) "*Weak Solutions of a Stochastic Landau-Lifshitz-Gilbert Equation Driven by Pure Jump Noise*"
11:50	Closing

Abstracts

"*Homogenization of ferromagnetic materials*"
François Alouges CMAP, CNRS et Ecole polytechnique, université Paris-Saclay, route de Saclay, 91128 Palaiseau Cedex, France.

Abstract

Some permanent magnets, e.g. spring magnets, are made of different compounds that are usually assembled together through an annealing process. The physical properties of such materials must be deduced from those of each component with the help of a homogenization procedure.

In this talk, we describe the homogenization process of both the energetical (Brown) and the time dependent (Landau-Lifschitz) models in periodic and stochastic settings. Focus will be done on the peculiarities of the model together with stochastic generalization of 2-scale convergence.

In terms of the energy, we use $\Gamma-$convergence type arguments, while for the time dependent equation, we proceed using properties of weak solutions. A particular care must be brought to the magnitude of the magnetization that stays constant inside each of the constituents.

This is a joint work with G. Di Fratta, A. de Bouard and B. Merlet.

"*Numerical approximation of the stochastic Cahn-Hilliard equation near the sharp interface limit*"
Lubomir Banas Department of Mathematics, Bielefeld University, 33501 Bielefeld, Germany

Abstract

We present an implicit semi-discrete numerical scheme for the stochastic Cahn-Hilliard equation with (asymptotically small) noise term. For the proposed scheme we derive strong convergence rates which depend polynomially on the interfacial thickness parameter. In addition, we perform numerical studies to show asymptotic behavior of the model.

This is a joint work with D. Antonopoulou (Chester) and A. Prohl (Tübingen).

"*Rough solutions of the Stochastic Navier-Stokes Equation*"
Björn Birnir Department of Mathematics and the Center for Complex and Nonlinear Science, University of California, Santa Barbara

Abstract

Recent comparison of theory and experimental data, from a variable density turbulence tunnel in Göttingen, Germany, indicates that the fluid velocity in homogeneous turbulence is not smooth but Hölder continuous with a Hölder exponent given by the Kolmogorov-Obukhov scaling and intermittency corrections. We review these result and present the existence theory of rough solutions in two-dimensions. Possible extension to the three-dimensional case will also be discussed.

"*On the hyperbolic conservation laws with noise: continuous dependence and approximations.*"
Imran H Biswas TIFR Centre for Applicable Mathematics, India.

Abstract

A large number of physical phenomenon could be mathematically described with the help of hyperbolic conservation laws. In view of the inherent complexities, it is very crucial to be able to account for possible randomness/noise in their descriptions. In this talk, we will try to make case for Lévy (jump-diffussion) type of noise and contend that it brings us a step closer to reality. We will describe some of the recent advances related to wellposedness, stability and approximations for stochastic conservation laws that are driven by Lévy noise.

"*Optimal weak convergence rates for discretization of SPDEs with multiplicative noise*"
Charles-Edouard Bréhier CNRS & Université Lyon 1, Institut Camille Jordan, Universit Claude Bernard Lyon 1, 43 boulevard du 11 novembre 1918, 69622 Villeurbanne cedex, France

Abstract

In this talk, we will consider semilinear, parabolic, SPDEs, with multiplicative noise of the form

$$dX(t) = AX(t)dt + F(X(t))dt + \sigma(X(t))dW(t),$$

where W is a cylindrical Wiener process, A is the Laplace operator with homogeneous Dirichlet boundary conditions on $H = L^2(0, 1)$, and coefficients F and σ are of class $\mathcal{C}^3$, with values in H and $\mathcal{L}(H)$ respectively.

In the case of additive noise, *i.e.* when σ is constant, it is known that the weak order of convergence for the time-discretization using the linear implicit Euler scheme is equal to $1/2$, and is thus twice the strong order $1/4$.

I will show that the same weak rate of convergence is obtained in the multiplicative noise case, without extra regularity assumption on the diffusion coefficient.

The fundamental ingredient of the proof is a new regularity result on the solution of the associated Kolmogorov equation: we go beyond previous results and prove that the same spatial regularization properties as in the additive noise case are satisfied. I will present the main ideas of the proof of this regularity result.

The talk is based on joint work with Arnaud Debussche (ENS Rennes).

"*Particle representations for SPDEs with boundary conditions*"
Dan Crisan Imperial College London, UK

Abstract

I will present a weighted particle representation for a class of stochastic partial differential equations with Dirichlet boundary conditions. The locations and weights of the particles satisfy an infinite system of stochastic differential equations (SDEs). The evolution of the particles is modeled by an infinite system of stochastic differential equations with reflecting boundary condition and driven by independent finite dimensional Brownian motions. The weights of the particles evolve according to an infinite system of stochastic differential equations driven by a common cylindrical noise W and interact through V , the associated weighted empirical measure. When the particles hit the boundary their corresponding weights are assigned a pre-specified value. We show the existence and uniqueness of a solution of the infinite dimensional system of stochastic differential equations modeling the location and the weights of the particles. We also prove that the associated weighted empirical measure V is the unique solution of a nonlinear stochastic partial differential equation driven by W with Dirichlet boundary condition. The work is motivated by and applied to the stochastic Allen-Cahn equation and extends the earlier of work of Kurtz and Xiong.

This is joint work with C. Janjigian (IHP) and T. G. Kurtz (Wisconsin-Madison) and is based on the paper Dan Crisan, Christopher Janjigian, Thomas G. Kurtz, Particle representations for stochastic partial differential equations with boundary conditions https://arxiv.org/abs/1607.08909

"*Nonlinear filtering with correlated Lévy noise characterized by copulas*"
Pani W. Fernando Montanuniversität Leoben, Austria

Abstract

The objective in stochastic filtering is to reconstruct the information about an unobserved (random) process, called the signal process, given the current available observations of a certain noisy transformation of that process.

Usually X and Y are modeled by stochastic differential equations driven by a Brownian motion or a jump (or Lévy) process. We are interested in the situation where both the state process X and the observation process Y are perturbed by coupled lévy processes. More precisely, $L = (L_1, L_2)$ is a 2–dimensional lévy process in which the structure of dependence is described by a lévy copula. We derive the associated Zakai equation for the density process and establish sufficient conditions depending on the copula and L for the solvability of the corresponding solution to the Zakai equation. In particular, we give conditions of existence and uniqueness of the density process, if one is interested to estimate quantities like $\mathrm{P}(X(t) > a)$, where a is a threshold.

"*Effective fractional wave equations in random multiscale media*"

Josselin Garnier Ecole Polytechnique

Abstract

Experiments show that seismic waves propagating through the earth's crust experience frequency-dependent attenuation. Three regimes have been experimentally identified with specific attenuation properties: the low-, mid-, and high-frequency regimes. We show that the observed behavior can be explained via theory for waves in random media. It considers multiple scattering of waves propagating in non-lossy one-dimensional random media with short- and long-range correlation properties. Using stochastic multiscale analysis it is possible to show that wave propagation is described by effective fractional equations that exhibit fractional damping exponents, which reproduce well the numerical simulations and the experimental attenuation properties in the low-, mid-, and high-frequency regimes.

Joint work with Knut Solna (UC Irvine)

"*Numerical simulations of metastable dynamics in stochastic partial differential equations*"

Ludovic Goudenège CNRS - Fédération de Mathématiques de CentraleSupélec
CentraleSupélec - Grande voie des vignes - Châtenay-Malabry - France

Abstract

When a realization of the noise can be easily computed, the numerical simulations of trajectory solution of stochastic partial differential equations are reduced to a deterministic task. In this way and with a heavy Monte-Carlo procedure we can obtain approximation of the law of solutions. But in case of metastable dynamics it could be very rare to see some instability, missing sometimes half of the density.

In this talk I will present an algorithm based on an adaptative multilevel splitting method which could be used in the context of stochastic partial differential equations with metastable dynamics. After a presentation of the algorithm in abstract space, I will speak about the special case of Allen-Cahn and Cahn-Hilliard equations.

In particular it is possible to visualize reactive trajectories i.e. trajectories which reach a stable state starting from another stable state, to compute transition times and probability of the transition with respect to the temperature.

This talk is based on a joint work with C.-E. Brhier, M. Gazeau, T. Lelivre and M. Rousset about unbiasedness of some Generalized Adaptive Multilevel Splitting algorithms published in The Annals of Applied Probability.

"*On localisation errors and fully discretised schemes for stochastic PDEs*"

Istvan Gyongy Edinburgh University

Abstract

We localise stochastic PDEs of parabolic type given in the whole Euclidean space in the spatial variable, by truncating the coefficients, the initial and free data outside of a ball. We show that the error caused by the truncation is exponentially small. We fully discretise the truncated equations, apply Richardson extrapolation, and estimate the errors independently of the truncations. The talk is based on joint results with N.V. Krylov and M. Gerencsr.

"*Numerical approximations for nonlinear stochastic partial differential equations*"

Arnulf Jentzen Department of Mathematics, ETH Zurich, Rämistrasse 101, 8092 Zürich, Switzerland

Abstract

The explicit, the linear-implicit, and the exponential Euler scheme are known to diverge strongly and numerically weakly when applied to a stochastic evolution equation (SEE) with a superlinearly growing nonlinearity. In this talk we propose a suitable nonlinearity-truncated explicit, full-discrete, and easily implementable modification of the exponential Euler scheme and we prove that the suggested scheme converges strongly and numerically weakly in the case of a large class of additive noise driven SEEs with possibly superlinearly growing nonlinearities. In particular, we establish strong and numerically weak convergence of the proposed scheme in the case of stochastic Allen-Cahn equations, stochastic Burgers equations, stochastic Kuramoto-Sivashinsky equations, Cahn-Hilliard-Cook equations, and two-dimensional stochastic Navier-Stokes equations. Thereafter, we present a few results on strong and weak convergence rates for numerical approximations of nonlinear SEEs.

"Strong convergence of a fully discrete finite element approximation of the stochastic Cahn-Hilliard equation"
Mihály Kovács Department of Mathematical Sciences, Chalmers University of Technology and University of Gothenburg, Sweden

Abstract

We consider the stochastic Cahn-Hilliard equation driven by additive smooth Gaussian noise in spatial dimension $d \leq 3$. We discretize the equation by a standard continuous finite element method is space and a fully implicit backward Euler method in time. We show that the numerical solution converges strongly to the solution of the stochastic Cahn-Hilliard equation as the discretization parameters vanish. This is a joint work with Daisuke Furihata, Stig Larsson and Fredrik Lindgren.

"Deterministic Continuation and CERES for Stochastically Forced PDEs"
Christian Kuehn Technical University of Munich, Faculty of Mathematics, Boltzmannstr. 3, 85748 Garching b. München, Germany

Abstract

In this talk I shall illustrate an approach to study the dynamics of stochastic PDEs (or more generally stochastic dynamical systems) with respect to parameters using deterministic continuation methods. In particular, I shall focus on the case of local fluctuations for the stochastic Allen-Cahn equation and explain the practical implementation as well as a novel framework for Combined ERror EStimates (CERES). This is joint work with Patrick Kürschner (MPI Magdeburg).

"Weak martingale solutions of stochastic Landau–Lifshitz–Gilbert equation coupled with Maxwell's equation"
Li Liang Montanuniversität Leoben, Austria

Abstract

The Landau–Lifshitz–Gilbert equations describe the evolution of the magnetization under a critical temperature. And the Maxwells equations describe how electric and magnetic fields are generated and altered by each other and by the magnetization. In this talk we are going to consider a stochastic Landau–Lifschitz–Gilbert equation coupled with the Maxwell's equation. The existence and some regularities of weak martingale solutions will be proved.

"Order of convergence of splitting schemes for both deterministic and stochastic nonlinear Schrödinger equations"
Jie Liu Department of Mathematics, National University of Singapore, Singapore 119076

Abstract

We first prove the second order convergence of the Strang-type splitting scheme for the nonlinear Schrödinger equation. The proof does not require commutator estimates but crucially relies on an integral representation of the scheme. It reveals the connection between Strang-type splitting and the midpoint rule. We then show that the integral representation idea can also be used to study stochastic nonlinear Schrödinger equation with multiplicative noise of Stratonovich type. Even though the nonlinear term there is not globally Lipschitz, we prove the first order convergence of a splitting scheme of it. Both schemes preserve the mass. They are very efficient because they use explicit formulas to solve the sub-problems containing the nonlinear or the nonlinear plus stochastic terms.

"Adaptive timestepping for S(P)DEs to control growth"
Lord Gabriel Heriot-Watt University, UK

Abstract

We introduce a class of adaptive timestepping strategies for stochastic differential equations arising from the semi-discretization of SPDEs with non-Lipschitz drift coefficients. These strategies work by controlling potential unbounded growth in solutions of a numerical scheme due to the drift. We prove that the Euler-Maruyama scheme with an adaptive timestepping strategy in this class is strongly convergent and present preliminary results on a semi-implicit scheme. We test this alternative to taming on some example SPDEs. This is joint work with Conall Kelly.

"*Weak Solutions of a Stochastic Landau–Lifshitz–Gilbert Equation Driven by Pure Jump Noise*"
Utpal Manna Indian Institute of Science Education and Research Thiruvananthapuram, India

Abstract

In this work we study a stochastic three-dimensional Landau-Lifschitz-Gilbert equation perturbed by pure jump noise in the Marcus canonical form. We show existence of weak martingale solutions taking values in a three-dimensional sphere $\mathbb{S}^2$ and discuss certain regularity results. The construction of the solution is based on the classical Faedo-Galerkin approximation, the compactness method and the Jakubowski version of the Skorokhod Theorem for nonmetric spaces. This is a joint work with Zdzislaw Brzezniak (University of York).

"*THE FORWARD-BACKWARD STOCHASTIC HEAT EQUATION: NUMERICAL ANALYSIS AND SIMULATION*"
Andreas Prohl Universität Tübingen

Abstract

I discuss the discretization of the the backward stochastic heat equation, and the forward-backward stochastic heat equation from stochastic optimal control. A full discretization based on finite elements, the implicit Euler method, and a least squares Monte-Carlo method, in combination with the new stochastic gradient method are then proposed, and simulation results are reported. - This is joint work with T. Dunst (U Tuebingen).

"*Simulation of heat waves in climate models using large deviation algorithms.*"
Francesco Ragone Departement of Earth and Environmental Sciences, University of Milano-Bicocca, Milan, Italy

Abstract

One of the goals of climate science is to characterize the statistics of extreme, potentially dangerous events (e.g. exceptionally intense precipitations, wind gusts, heat waves) in the present and future climate. The study of extremes is however hindered by both a lack of past observational data for events with a return time larger than decades or centuries, and by the large computational cost required to perform a proper sampling of extreme statistics with state of the art climate models. The study of the dynamics leading to extreme events is especially difficult as it requires hundreds or thousands of realizations of the dynamical paths leading to similar extremes. We will discuss here a new numerical algorithm, based on large deviation theory, that allows to efficiently sample very rare events in complex climate models. A large ensemble of realizations are run in parallel, and selection and cloning procedures are applied in order to oversample the trajectories leading to the extremes of interest. The statistics and characteristic dynamics of the extremes can then be computed on a much larger sample of events. This kind of importance sampling method belongs to a class of genetic algorithms that have been successfully applied in other scientific fields (statistical mechanics, complex biomolecular dynamics), allowing to decrease by orders of magnitude the numerical cost required to sample extremes with respect to standard direct numerical sampling. We study the applicability of this method to the computation of the statistics of European surface temperatures with the Planet Simulator (Plasim), an intermediate complexity general circulation model of the atmosphere. We demonstrate the efficiency of the method by comparing its performances against standard approaches. Dynamical paths leading to heat waves are studied, enlightening the relation of Plasim heat waves with blocking events. We then discuss the feasibility of this method for applications with state of the art climate models, and we explain why this new approach could represent a change of paradigm for the study of extreme events, allowing to study their dynamics extensively at a reasonable computational cost. This work has been carried on at the cole Normale Suprieure de Lyon together with Freddy Bouchet (Laboratoire de Physique, cole Normale Suprieure de Lyon, Lyon, France) and Jeroen Wouters (School of Mathematics and Statistics, University of Sydney, Sydney, Australia).

"*Time discretization of stochastic Langrangian Averaged Euler equations on non-smooth domain*"
Paul Razafimandimby University of Pretoria, South-Africa

Abstract

In this talk we will present some how we can construct weak martingale solution of the stochastic Lagrangian Averaged Euler equations on a bounded Lipschitz domain O. We will also report on the pathwise uniqueness and time-regularity of the solutions.

"*Multilevel Subset Simulation for Rare Events*"

Robert Scheichl Department of Mathematical Sciences, University of Bath

Abstract

In this talk I will present a multilevel conditional estimator for rare event probabilities. The underlying approach has been proposed in several communities under various names. We will base our work on the methodology proposed by [Au & Beck, 2001] in the engineering community under the name of *subset simulation*. In statistics, it is sometimes referred to as *importance splitting*. It has also strong links to sequential Monte Carlo methods and so-called *shaking transformations* (Gobet & Liu, 2015).

Our proposed estimator uses different model resolutions and varying numbers of samples on the hierarchy of failure sets. We construct the failure sets such that a high number of samples are used when the model evaluations are cheap, while only using a small number of expensive samples, in order to reduce the computational cost. A key idea in our new estimator is the use of a posteriori error estimation to guarantee the critical subset property that may be violated when changing model resolution from one failure set to the next. The error estimators also allow to avoid expensive calculations for samples that are far away from the boundary of our failure sets. The computational gains are demonstrated on a model elliptic PDE with random coefficients. Some possible extensions to other applications will also be given. This is joint work with Daniel Elfverson (Umeå).

" *Beam-wave backscattering in random multiscale media*"

Knut Solna University of Cailfornia at Irvine

Abstract

Experiments show that wave back-scattering from complex media, like the earth's crust, exhibit a so called enhanced backscattering cone. We discuss an iterative two-way paraxial scheme for the simulation of wave propagation in 3D random media that can capture such backscattering effects . This scheme has the computational cost of the standard one-way paraxial wave equation but has the accuracy of the full wave equation in a regime beyond the classical paraxial regime. More precisely, it accurately predicts the statistics of the reflected wave field and we summarize the probabilistic analysis of this.

Joint work with Josselin Garnier (Ecole Polytechnique)

"*Stochastic Nerve Axon Equations*"

Wilhelm Stannat TU Berlin

Abstract

When modelling neural activity in the brain, stochasticity on the molecular level, for example channel noise and synaptic noise, has to be taken into account.

In the talk I will introduce a mathematical framework to analyze in a rigorous way stochastic conductance based neuronal models describing the propagation of action potentials travelling along the nerve axon under the impact of channel noise fluctuations.

The resulting stochastic evolution systems exhibit a rich phenomenology, like propagation failure, backpropagation, spontaneous pulse solutions and annihilation of pulses, that cannot be modelled with their deterministic counterparts.

We present existence and uniqueness results, as well as results on the numerical numerical approximation, and demonstrate how to deduce within this framework a random ordinary differential equation describing the speed of the action potential that gives rise to a multiscale analysis of the whole dynamical system.

References:

M. Sauer, W.Stannat: Reliability of signal transmission in stochastic nerve axon equations, Journal of Computational Neuroscience 40, pp. 103-111, 2016.

M. Sauer, W.Stannat: Analysis and Approximation of Stochastic Nerve Axon Equations, Math. Comp. 85, pp. 2457-2481, 2016.

M. Sauer, W.Stannat: Lattice Approximation for Stochastic Reaction Diffusion Equations with One-sided Lipschitz Condition, Math. Comp. 84, pp. 743-766, 2015

"*Sensitivity analyses w.r.t. the noise and the coefficients of stochastic differential equations*"
Denis Talay Inria and Ecole Polytechnique

Abstract

In the talk I will discuss two quite different sensitivity analyses of stochastic differential equations: 1) The sensitivity of diffusion models to the Hurst parameter of the noise; 2) The effective computation of a Wasserstein-type distance between two martingale problem solutions.

I will present quite recent results obtained in collaboration with Alexandre Richard (problem 1) and Jocelyne Bion-Nadal (problem 2).

"*Branching particles representation for nonlinear PDEs*"
Nizar Touzi Department of Mathematics, Bielefeld University, 33501 Bielefeld, Germany

Abstract

We provide a representation of the solution of a semilinear partial differential equation by means of a branching diffusion. Unlike the backward SDE approach, such a representation induces a purely forward Monte Carlo method. We also provide applications to the unbiased simulation of stochastic differential equations, and extensions to general initial value problems.

"*Approximation of stochastic scalar conservation laws by the Finite Volume method*"
Julien Vovelle Université Claude Bernard Lyon 1

Abstract

We develop a general framework to prove the convergence of approximations to stochastic first-order scalar conservation laws and then apply it to obtain convergence results for numerical approximations computed by the Finite Volume method. Joint work with Sylvain Dotti (Aix-Marseille University).

"*Numerical Approximation of Parabolic SPDE's*"
Noel J. Walkington
Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA, USA

Abstract

A general convergence theory for numerical schemes to approximate solutions of stochastic parabolic equations of the form form

$$du + A(u)\,dt = f\,dt + g\,dW, \qquad u(0) = u^0,$$

will be reviewed. Here u is a random variable taking values in a function space U, $A : U \to U'$ is partial differential operator, $W = \{W_t\}_{t\geq 0}$ a Wiener process, and f, g, and u^0 are data. By combining ideas from stochastic analysis and numerical partial differential equations a realization of the Lax–Richtmeyer meta–theorem

A numerical scheme converges if (and only if) it is stable and consistent.

is developed. Granted sufficient structure of the differential operator(s) to establish stability, the key step is to establish a version of Donsker's theorem for discrete processes in the dual space U'.

This is joint work with A. Prohl (U. Tuebingen, DE).

"*On a pseudomonotone evolution equation with multiplicative noise*"

Aleksandra Zimmermann Faculty of Mathematics, University of Duisburg-Essen, 45117 Essen

Abstract

Let $(\Omega, \mathcal{F}, \mathbb{P})$ be a complete, countably generated probability space, $T > 0$, $D \subset \mathbb{R}^d$ be a bounded Lipschitz domain, $Q_T := (0,T) \times D$ and $p > 2$. Our aim is the study of the problem

$$(P)\begin{cases} du - \operatorname{div}(|\nabla u|^{p-2}\nabla u + F(u))\ dt = H(u)\ dW & \text{in } \Omega \times Q_T \\ u = 0 & \text{on } \Omega \times (0,T) \times \partial D \\ u(0,\cdot) = u_0 \in W_0^{1,p}(D) \end{cases}$$

for a cylindrical Wiener process W in $L^2(D)$ with respect to a filtration $(\mathcal{F}_t)$ satisfying the usual assumptions and $F : \mathbb{R} \to \mathbb{R}^d$ Lipschitz continuous. We consider the case of multiplicative noise with $H : L^2(D) \to HS(L^2(D))$, $HS(L^2(D))$ being the space of Hilbert-Schmidt operators, satisfying appriopriate regularity conditions. By an implicit time discretization of (P), we obtain approximate solutions. Using the theorems of Skorokhod and Prokhorov, we are able to pass to the limit and show existence of martingale solutions. Using an argument of pathwise uniqueness, we show existence and uniqueness of strong solutions.

Abstracts for Posters

"New Applications of Fractional Calculus on Random Variables"

Zoubir DAHMANI Laboratory LPAM, Faculty of SEI, UMAB University

Abstract

New concepts of fractional calculus applied to probabilistic random variables are introduced. Some classical probabilistic results are generalized and some applications for the $\alpha-$expectations and for the $(r, \alpha)-$moments are discussed.

"Wind Energy Procurement with Brownian-Lévy processes in Electricity Portfolios"

Genaro Longoria Telecommunications Software and Systems Group, Carriganore Campus, Carriganore, Co. Waterford, Ireland, X91 P20H

Abstract

To leverage the potential of integrating renewable sources into electricity portfolios, a major concern of Load Serving Entities (LSE) is to minimize the total procurement cost while fulfilling its committed demand. From the perspective of a LSE, we study the energy allocation strategies from two type of markets: bilateral long-term contracts and real-time trading. Electricity is procured from two different sources: wind energy and conventional generation. We present a model for the procurement costs of the energy prices on both markets and from both electricity sources. Based on our approach, we present an algorithm where real-time price dynamics are the solution to a Lévy process stochastic differential equation (SDE). The wind energy availability is modeled with a SDE transformed to a relevant probability density function. Portfolio Theory is used to asses the allocation strategies. We present the efficient frontier and a self-defined acceptable risk level. We empirically demonstrate by simulations the wind integration feasible portfolio ranges and the risk associated. LSE may use the proposed algorithm to obtain insights on their electricity portfolio diversification.

"Strong Solutions of Stochastic Models for Viscoelastic Flows of Oldroyd Type"

Debopriya Mukherjee Indian institute of science education and research, India

Abstract

I would like to give a poster presentation on my recent work analysing stochastic Oldroyd type models for viscoelastic fluids in $\mathbb{R}^d, d = 2, 3$. In this work, we study the existence, uniqueness and regularity of strong local maximal solutions when the initial data are in H^s for $s > d/2, d = 2, 3$. Probabilistic estimate of the random time interval for the existence of a local solution is expressed in terms of expected values of the initial data. This is a joint work with Dr. Utpal Manna (Associate Professor, Indian Institute Of Science Education and Research, Thiruvananthapuram, Kerala) .

"Importance Sampling techniques for stochastic partial differential equations"

Andreas Thalhammer Johannes Kepler University, Linz

Abstract

In this work, we consider Monte Carlo-based methods for estimating $\mathbb{E}[f(X(T))]$, where $X(T)$ denotes the mild solution of a stochastic partial differential equation (SPDE) at a given time T. It is a well-known result that the resulting Monte Carlo error can be controlled by either enlarging the number of realisations or by applying appropriate variance reduction methods. Obviously, a natural bound on the number of trajectories is imposed by the computational cost of the time integration method, which limits the possibility of increasing the number of numerical trajectories for high dimensional SODEs - especially for systems arising from semi-discretised SPDEs. For this reason, we present two different approaches how importance sampling can be applied to SPDEs in order to reduce the variance of the quantity of interest. The first approach is based on a finite-dimensional measure transformation and is used in the context of rare event simulation for semi-discretised SPDEs, whereas the second approach extends these results to an infinite-dimensional framework. Numerical experiments show the effectiveness of the proposed methods.

List of Participants

Abouelella	Dina	Cairo University
Alouges	François	CMAP Ecole Plythechnique
Banas	Lubonir	Bielefeld University
Bilitewski	Sonja	University of Duisburg-Essen
Birnir	Björn	Univ. of California, Santa Barbara
Biseh	Imran	
Biswas	Imran Habib	Tata Institute of Fundamental Research
Bréhier	Charles-Edouard	CNRS and Université Lyon1
Crisan	Dan	Imperial College London UMAB
Dahmani	Zoubir	University of Mostaganem
Danyk	Anton	Taras Shevchenko National University of Kyiv
Fajar	Rifaldy	Yogyakarta Sate University
Fernando	Pani W.	Montanuniversität Leoben
Gangl	Peter	JKU Linz
Garnier	Josselin	Ecole Polytechnique
Goudenege	Ludovic	CNRS
Guglielmi	Roberto	RICAM
Gyongy	Istvan	Edinburgh University
Hausenblas	Erika	Montanuniversität Leoben
Jentzen	Arnulf	ETH Zurich
Jodlbauer	Daniel	JKU Linz
Kalise	Dante	RICAM
Khaksar	Ghalati	Coimbra University
Kovàcs	Mihaly	Chalmers University and University of Gothenburg
Kuehn	Christian	TU München
Leobacher	Gunther	JKU Linz
Liu	Jie	
Longoria	Genaro	TSSG Ireland
Lord	Gabriel	Heriot-Watt University
Matculevich	Svetlana	RICAM
Motyl	Ela	Polen
Osterbrink	Frank	
Pauly	Dirk	University Duisburg-Essen
Poncet	Romain	CMAP Ecole Polytechnique
Ragone	Francesko	
Randrianasolo	Tsiry Avisoa	Montanuniversität Leoben
Ranetbauer	Helene	RICAM
Razafimandimby	Paul André	University of Pretoria
Repin	Sergey	Steklov Institute
Rodrigues	Sergio	RICAM
Rozovskii	Boris	
Scheichl	Robert	University of Bath
Schomburg	Michael	
Sebastian	Daniel	University of Duisburg-Essen
Solna	Knut	University of California at Irvine
Stannat	Wilhelm	TU Berlin
Szölgyenyi	Michaela	Vienna University of Economics and Business
Takacs	Stefan	INRIA
Talay	Denis	INRIA
Thalhammer	Andreas	JKU Linz
Touzi	Nizar	Ecole Polytechnique
Vovelle	Julien	CNRS-ICJ
Walkington	Noel	Carnegie Mellon University
Wattson	Rodolfo	Costa Rica
Weber	Hendrik	
Wolfmayr	Monika	RICAM
Zimmermann	Aleksandra	University Duisburg-Essen

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00-8:50	Registration				
8:50-9:00	Opening				
9:00-9:50	Nizar Touzi *“Branching particles representation for nonlinear PDEs”*	Wilhelm Stannat *“Stochastic Nerve Axon Equations“*	Noel Walkington *“Numerical Approximation of Parabolic SPDE’s”*	Charles-Edouard Brehier *“Optimal weak convergence rates for discretization of SPDEs with multiplicative noise”*	Francesco Ragone *“Simulation of heat waves in climate models using large deviation algorithms”*
9:50-10:40	Dan Crisan *“Particle representations for SPDEs with boundary conditions””*	Mihály Kovács *“Strong convergence of a fully discrete finite element approximation of the stochastic Cahn-Hilliard equation”*	Imran Biswas *“On the hyperbolic conservation laws with noise: continuous dependence and approximations””*	Gabriel Lord *“Adaptive timestepping for S(P)DEs to control growth”*	Li Liang *“Weak martingale solutions of stochastic Landau–Lifshitz–Gilbert equation coupled with Maxwell’s equation”*
	Coffee	*Coffee*	*Coffee*	*Coffee*	*Coffee*
11:00–11:50	Arnulf Jentzen *“Numerical approximations for nonlinear stochastic partial differential equations”*	Andreas Prohl *“The Forward–Backward stochastic heat equation: numerical analysis and simulation”*	Istvan Gyöngy *“On localisation errors and fully discretised schemes for stochastic PDEs”*	Julien Vovelle *“Approximation of stochastic scalar conservation laws by the Finite Volume method”*	Utpal Manna *“Weak Solutions of a Stochastic Landau-Lifshitz-Gilbert Equation Driven by Pure Jump Noise”*
11:50-12:40	Francois Alouges *“Homogenization of ferromagnetic materials”*	Josselin Garnier *“Effective fractional wave equations in random multiscale media”*	Paul Razafimandimby *“Time discretization of stochastic Langrangian Averaged Euler equations on non-smooth domain”*	Liu Jie *“Order of convergence of splitting schemes for both deterministic and stochastic nonlinear Schrödinger equations”*	**Closing at 11:50**
	Lunch	*Lunch*	*Lunch*	*Lunch*	
14:30-15:20	Björn Birnir *“Rough solutions of the Stochastic Navier-Stokes Equation”*	Denis Talay *“Sensitivity analyses w.r.t. the noise and the coefficients of stochastic differential equations”*	Christian Kühn *“Deterministic Continuation and CERES for Stochastically Forced PDEs“*	Lubomir Banas *“Numerical approximation of the stochastic Cahn-Hilliard equation near the sharp interface limit”*	
15:20-16:10	Pani Fernando *“Nonlinear Filtering with correlated Lévy noise characterized by copula”*	Knut Solna *“Beam-wave backscattering in random multiscale media”*	*excursion to advent market (please feel free to make use of the seminar room and the Special Semester offices)*	Robert Scheichl *“Multilevel Subset Simulation for Rare Events”*	
16:10-17:00	**Poster session & Reception**	Ludovic Goudenège *”Numerical simulations of meta stable dynamics in stochastic partial differential equations“*			
19:00		**Dinner**			