Conference, Hammamet, 17 - 21. October 2022

Recent developments in Stochastics with applications in Mathematical Physics and Finance

This event is organised by the collaboration of

- Giulia Di Nunno (STORM and University of Oslo)
- Martin Friesen (Dublin City University)
- Asma Khedher (University of Amsterdam)
- Habib Ouerdiane (Tunis El-Manar University, local organiser)
- Barbara Rüdiger (Wuppertal University)

List of speakers and abstracts

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Limit theorems for time averages of continuous-state branching processes with immigration

Abstract: In our work we investigate limit theorems for the time-averaged process

$$\left(\frac{1}{t}\int_0^t X_s^x ds\right)_{t\geq 0}$$

where X^x is a subcritical continuous-state branching processes with immigration (CBI processes) starting in $x \geq 0$. Under a second moment condition on the branching and immigration measures we first prove the law of large numbers in L^2 and afterward establish the central limit theorem. Assuming additionally that the big jumps of the branching and immigration measures have finite exponential moments of some order, we prove in our main result the large deviation principle and provide a semi-explicit expression for the good rate function in terms of the branching and immigration mechanisms. Our methods are deeply based on a detailed study of the corresponding generalized Riccati equation and related exponential moments of the time-averaged process.

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Hidden Markov processes: classical and quantum

Abstract: In the past 20 years the number of applications of Hidden Markov processes (HMP) (also called Hidden Markov models (HMM)) has soared, covering disciplines as machine learning, speech or handwriting recognition, image reconstruction, mathematical finance, ion channels, ... However the available mathematical literature on HMP is not very satisfactory for several reasons. For example in this literature one can Find two different classes of process,

both called HMP. The talk consist of two parts: the first one gives a mathematically precise definition of HMP in algebraic language. The second part will be devoted to the quantum case, first dealing with the general theory, then showing that the simplest class of quantum Markov chains, when restricted to any diagonal algebra, gives a HMP. This shows that, for model building in any discipline, quantum Markov chains are a much more flexible and powerful tool than classical HMP because they allow, with the same (finite) number of parameters, to deal simultaneously with infinitely many classical HMP.

This is joint work with Soueidy El Gheteb, Yun Gang Lu and Abdessatar Souissi.

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Analysis of infectious disease transmission and prediction through SEIQR epidemic model/ Or A New Technique of ECG Denoising based on LWT

Abstract: In this work, we propose conceptual mathematical model through a SEIQR (Susceptible-Exposed-Infected-Quarantined-Recovered) mathematical model and its control measurement. We establish the positivity and boundedness of the solutions. We also compute the basic reproduction number and investigate the stability of equilibria for its epidemiological relevance. / In this work we propose a new technique of Electrocardiogram (ECG) denoising. This technique is based on Lifting Wavelet Transform (LWT) and Total variation based denoising technique using majorization-minimization.

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Self-similar Gaussian Markov processes

Abstract: We characterize all finite dimensional centered self-similar Gaussian Markov processes via the structure of their covariance kernels. In the one dimensional case this leads to a two parameter family of Gaussian Markov processes such that any centered self-similar Gaussian Markov process is a constant multiple of a process from this family. This yields short and easy proofs of some non-Markovianity results concerning variants of fractional Brownian motion (most of which are known). In the proof, we relate the covariance kernels to certain growth bounded one-parameter matrix semigroups.

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Optimal guaranteed estimation methods for the Cox-Ingersoll-Ross (CIR) models

Abstract: In this paper we study parameter estimation problems for the Cox - Ingersoll - Ross (CIR) processes. For the first time for such models sequential estimation procedures are proposed. In the non-asymptotic setting, the proposed sequential procedures provide the estimation with non-asymptotic fixed mean square accuracy. For the scalar parameter estimation problems non-asymptotic normality properties for the proposed estimators are established even in the cases when the classical non sequential maximum likelihood estimators can not be calculated. Moreover, the Laplace transformations for the mean observation durations are obtained. In the asymptotic setting, the limit forms for the mean observation durations are founded and it is shown, that the constructed sequential estimators uniformly converge in distribution to normal random variables. Then using the Local Asymptotic Normality (LAN) property it is obtained asymptotic sharp lower bound for the minimax risks in the class of all sequential procedures with the same mean observation duration and as consequence, it is established, that the proposed sequential procedures are optimal in the minimax sens in this class.

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Recent results in Generalized Grey Brownian Motion

Abstract: In this talk we discuss recent results in Mittag-Leffler Caculus and for Generalized Brwonian Motion. Among them are an integral formula and SDEs.

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Stochastic near-optimal control for drug therapy in a random viral model with cellular immune response

Abstract: Near-optimization is important as optimization for theory of stochastic control and appli- cations. In this work, we consider a stochastic viral model incorporating the lytic and nonlytic immune responses where the system is governed by stochastic differential equa- tions (SDE's). According to the adjoint equations, we estimate the error bound for the near optimality. Then, using the Hamiltonian function, Ekeland's variational principle and some basic estimates for state processes and adjoint processes , we will prove sufficient and necessary conditions to minimize the cost functional. Using control treatment, numerical illustrations are introduced to compare with theoretical.

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Gradings on White Noise Lie Algebras

Abstract: We study Lie algebras of white noise operators containing quantum white noise derivatives of the conservation operator and the generalized Gross Laplacian. Properties such as solvability, nilpotency, and semisimplicity are investigated. Moreover, gradings on these Lie algebras are introduced. We describe Lie algebras isomorphic to the infinite dimensional filiform Lie algebra, Carnot algebra, solvable Lie algebra with Heisenberg ideals, among others. This is joint work with W. Bock of Kaiserslautern University.

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Non-Gaussian analysis based on a class of completely monotone functions

Abstract: During the last decades infinite-dimensional analysis has been developed through the use of non-Gaussian measures. Indeed, the tools of White Noise Analysis have been generalized for non-Gaussian measures to obtain notions and characterizations similar to Gaussian Analysis. In this talk, we present the cases of measures and generalized processes based on the Gamma incomplete function and a larger class of completely monotone functions.

Christa Cuchiero
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Measure-valued processes for energy markets

Abstract: We introduce a framework that allows to employ (non-negative) measure-valued processes for energy market modeling, in particular for electricity and gas futures. Interpreting the process' spatial structure as time to maturity, we show how the Heath-Jarrow-Morton (HJM) approach can be translated to this framework, thus guaranteeing arbitrage free modeling in infinite dimensions. We derive an analog to the HJM-drift condition and then treat in a Markovian setting existence of (non-negative) measure-valued diffusions that satisfy this condition. To analyze convenient classes we consider measure-valued polynomial and affine diffusions, where we can precisely specify the diffusion part. Indeed, it depends on continuous functions satisfying certain admissibility conditions. For calibration purposes these functions can then be parametrized by neural networks yielding measure-value analogs of neural SPDEs. This then allows for tractable calibration procedures via the moment formula and Fourier approaches as well as stochastic gradient descent methods where the gradients can be computed analytically.

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Asymptotic properties of $AM(1,n)$ model and its maximum likelihood estimator

Abstract: This talk deals with the problem of global parameter estimation of $AM(1,n)$ where n is a positive integer which is a subclass of affine diffusions introduced by Duffie, Filipovic, and Schachermayer. The $AM(1,n)$ model is applied to the pricing of bond and stock options, which is illustrated for the Vasicek, Cox-Ingersoll-Ross and Heston models. Our first result is about the classification of $AM(1,n)$ processes according to the subcritical, critical and supercritical cases. Then, we establish the stationarity and the ergodicity theorems and we give asymptotic properties of the maximum likelihood estimator.

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Horizon risk and fully dynamic risk measures

Abstract: We consider the risk of performing a risk assessment with measures that are not adequate to the actual time horizon, this is essentially what we call horizon risk. We then study fully-dynamic risk measures in this perspective and consider the associated notions of consistency, which we study in connection to other properties such as normalisation and restriction. We detail the connection between fully-dynamc risk measures and backward SDE, a family of backward SDEs, Volterra type backward SDEs, and a family of Volterra BSDEs.

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On Reflected Backward Stochastic Differential Equations driven by time-changed Levy noise

Abstract: Reflected backward stochastic differential equations with a left/lower barrier (RBSDEs with lower barrier) with time-changed Levy are introduced. The time change process is here independent of the Levy bases considered. We study existence and uniqueness of the solution of RBSDE with left barrier under natural filtration $\mathbf{F}$ of the noise and also under an enlarged filtration $\mathbf{G}$, which contains additional information on the time-change process. Furthermore, a comparison principle for the RBSDEs is obtained.

This is joiny work with Prof. Giulia Di Nunno.

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White Noise calculus for time change processes

Abstract: In this work, we investigate the time change process $\Lambda(t)$ in the framework of infinite dimensional analysis and especially in the theory of White Noise calculus. Using the Bochner-Minlos theorem, we introduce on the dual of the Schwartz space a conditional measure associated to the process of the time change $\Lambda(t)$. This conditional measure is a generalization of the classical Gaussian measure in the white Noise distribution theory when $\Lambda(t) = t$. Next we provide a generalization of Hida and Potthof distributions spaces associated to this conditional measure. Then we prove that the Brownian motion at the process $\Lambda(t)$ is a martingale with respect to an associated enlarged filtration and we obtain the associated Clak Ocone formula.

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Pathwise Inverse problem in concave optimization

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Change of measure in a Heston-Hawkes stochastic volatility model

Abstract: We consider the stochastic volatility model obtained by adding a compound Hawkes process to the volatility of the well-known Heston model. A Hawkes process is a self-exciting counting process with many applications in mathematical finance, insurance, epidemiology, seismology and other fields. We prove a general result on the existence of a family of equivalent (local) martingale measures. We apply this result to a particular example where the size of the jumps are exponentially distributed. Finally, we also give the dynamics of the forward variance which can be used to add a tradable asset in this model.

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Long-time behavior of affine Volterra processes

Abstract: In this talk, we study the long-time behavior of affine Volterra processes on the state space $\mathbb{R}_+^m$. Based on a detailed study of the Volterra Riccati equation, we analyze possible limit distributions and subsequently prove the law of large numbers as well as the central limit theorem for the long-term mean volatility. Moreover, for each limit distribution, we construct the corresponding stationary process and express its f.d.d. in terms of solutions to a generalized system of Volterra Riccati equations. In dimension one, our results show that limit distributions and stationary processes are unique (despite the presence of memory in the model) if and only if the Volterra kernel is integrable.

This work is joint with P. Jin.

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Pricing options on flow forwards by neural networks in Hilbert space

Abstract: We propose a new methodology for pricing options on flow forwards by applying infinite-dimensional neural networks. We recast the pricing problem as an optimisation problem in a Hilbert space of real-valued function on the positive real line, which is the state space for the term structure dynamics. This optimisation problem is solved by facilitating a novel feedforward neural network architecture designed for approximating continuous functions on the state space. The proposed neural net is built upon the basis of the Hilbert space. We provide an extensive case study that shows excellent numerical efficiency, with superior performance over that of a classical neural net trained on sampling the term structure curves.

This is a joint work with Fred Espen Benth (UiO) and Nils Detering (University of California Santa Barbara).

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Signature-based models: theory and calibration

Abstract: We consider asset price models whose dynamics are described by linear functions of the (time extended) signature of a primary underlying process, which can range from a (market-inferred) Brownian motion to a general multidimensional continuous semimartingale. The framework is universal in the sense that classical models can be approximated arbitrarily well and that the model's parameters can be learned from all sources of available data by simple methods. We provide conditions guaranteeing absence of arbitrage as well as tractable option pricing formulas for so-called sig-payoffs, exploiting the polynomial nature of generic primary processes. One of our main focus lies on calibration, where we consider both time-series and implied volatility surface data, generated from classical stochastic volatility models and also from S&P500 index market data. For both tasks the linearity of the model turns out to be the crucial tractability feature which allows to get fast and accurate calibrations results. This presentation is based on a joint work with Christa Cuchiero and Sara Svaluto-Ferro.

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General Equilibrium with Unhedgeable Fundamentals and Heterogeneous Agents

Abstract: We solve a general equilibrium model in which aggregate consumption has uninsurable growth shocks, rendering the market dynamically incomplete. Several long-lived agents with heterogeneous risk-aversion and time-preference make consumption and investment decisions, trading risky assets and borrowing from and lending to each other. For small growth fluctuations, we obtain closed-form expressions for stock prices, interest rates, and consumption and trading policies. Agents' stochastic discount factors depend on the history of unhedgeable shocks, agents trade assets dynamically, and the dispersion of agents' preferences impacts both the interest rate and asset prices, hence no representative agent exists.

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A Kalman filter based dimension reduction approach for pricing grid

Abstract: Pricing grids are widely used among financial institutions to revaluate the portfolios when assessing the potential risks, for instance credit risk or market risks. When applying the pricing grid for the revaluation, the biggest challenge is the ”curse of dimensionality”. Therefore, a dimension reduction approach is usually required to project the higher dimensional risk factors to the lower dimensional factors. In this talk, we propose a Kalman filter based dimension reduction approach and we will specially focus on the application in the credit risk calculations

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Spatial convergence for backward doubly stochastic differential equations in infinite dimensions: a mild approach

Abstract: In this paper we present convergence results of a spatial semi-discrete approximation of a Hilbert space-valued nonlinear backward doubly stochastic differential equation with noise driven by a cylindrical Q-Wiener process. Both the solution and its space discretization are formulated in mild forms. Under suitable assumptions of the final value and the driver, a convergence rate is established.

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A semi-static replication method for callable interest rate derivatives

Abstract: We present a semi-static replication algorithm for Bermudan swaptions under an affine, multi-factor term-structure model. In contrast to dynamic replication, which needs to be continuously updated as the market moves, a semi-static replication needs to be rebalanced on just a finite number of instances. We show that the exotic derivative can be decomposed into a portfolio of vanilla discount bond options, which mirrors its value as the market moves and can be priced in closed form. This paves the way to efficient numerical simulation of xVA, market- and credit risk metrics for which forward valuation is the key ingredient. The static portfolio composition is obtained by regressing the target option's value using an interpretable, artificial neural network. Leveraging the universal approximation power of neural networks, we prove that the replication error can be arbitrarily small for a sufficiently large portfolio. A direct, a lower bound, and an upper bound estimator for the Bermudan swaption price can be inferred from the replication algorithm. Additionally, error margins to the price statistics can be determined in closed-form. We practically demonstrate the accuracy of the method through several numerical experiments.

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Interacting particles and market capitalizations

Abstract: Motivated by the robustness of the so-called market capitalization curve, our goal is to study the behaviour of equity market models on a macroscopic scale. This is done by extending the volatility stabilized market models studied by Fernholz and co-authors and allowing for simple correlation structure induced by a common noise term. Letting the number of companies approach infinity, we show that the limit of the empirical measure of the N-company system converges to the unique solution of a degenerate, non-linear SPDE. The obtained limit also possess a representation as a conditional probability of the solution to a certain McKean-Vlasov SDE.

This is joint work in progress with Christa Cuchiero.

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Geometric models inducing the Ornstein-Uhlenbeck phenomenon

Abstract: By the mean of geometric models, we present the Airault-Malliavin-Ouerdiane approach for constructing and studying stochastic flow process living in some complex domain. We shall explain this method via the Segal-Bargmann-Kirillov model.

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A new approach on stochastic integration of non-adapted processes with respect to fractional Brownian motion.

Abstract: In this work, we present property of instant independence and we give a new approach on stochastic integration with respect to fractional Brownian motion for processes not necessarily adapted.

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A characterisation and analysis of infinite-dimensional Wishart processes

Abstract: In this article, we provide a characterisation result for the existence of Wishart processes in the cone of positive trace class operators with an initial condition which is of finite rank. Moreover, we derive the Laplace transform of such processes and study their Feller property.
This is based on a joint work with Christa Cuchiero and Sonja Cox.

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Explosion and non-explosion for the continuous-time frog model

Abstract: Different sets of conditions are given ensuring the explosion, respectively non-explosion, of the continuous-time frog model. The proof relies on a certain type of comparison to a percolation model which we call totally asymmetric discrete inhomogeneous Boolean percolation.
Joint work with Viktor Bezborodov and Luca Di Persio.

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Renewal theory approach to the mean square analysis of stochastic equations with memory

Abstract: The long term behaviour of the mean square of stochastic functional differential equations (SFDEs) has received a great deal of study in recent decades. In this talk we are concerned with the renewal theory approach to such asymptotic analysis which, compared to other methods, has received far less attention. This method was first introduced by Appleby, Mao and Riedle (2009) to which they studied a scalar linear SFDE with distributed delay in the drift and diffusion terms. To the best of our knowledge, this was the first attempt to provide necessary and sufficient conditions that ensure mean square stability, however the conditions that resulted were hard to check and not in terms of the problem data. We give a comprehensive review of the renewal approach and present recent advances that see this method applied to equations in both discrete and continuous time. We outline the cases where progress has been made to deduce stability conditions in terms of the problem data as well as deriving a stochastic characteristic equation whose solution gives the rate of growth or decay of the mean square.

References: Appleby, J.A.D.,Mao, X. and Riedle,M. (2009) ‘Geometric Brownian motion with delay: mean square characterisation’, Proceedings of the American Mathematical Society, Vol. 137, pp.339–348.

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Functional Central Limit Theorems and $P(\phi)$1-Processes for the Relativistic and Non-Relativistic Nelson Models

Abstract: We construct $P(\phi)$1-processes indexed by the full time-line, separately derived from the functional integral representations of the relativistic and non-relativistic Nelson models in quantum field theory. These two cases differ essentially by sample path regularity. Associated with these processes we define a martingale which, under an appropriate scaling, allows to obtain a central limit theorem for additive functionals of these processes. We discuss a number of examples by choosing specific functionals related to particle-field operators.

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Optimal harvesting under marine reserves and uncertain environment.

Abstract: Persistence in the literature is the perception of an inherent tradeoff between ecological conservation and economic harvesting goals. Overexploitation may lead to resource destruction, including extinction. Conservation measures should be decided and implemented. A standard ecological response is to impose no-take areas or marine reserves. In this work, our objective is to study a harvesting management problem under the constraints of a no-take area, which we formulate mathematically as a bi-dimensional singular stochastic control problem. Using dynamic programming theory, we characterise our value function as the unique solution

to a HJB equation. We also describe the optimal harvesting strategy by identifying the harvesting and non-harvesting regions. We show that setting up a reserve area not only leads to a better ecological conservation but may also increase the economic benefit for the fishing industry in the long run. We further enrich our studies with some numerical analysis, enabling us to get some insightful understanding on the size of the reserve area where no-take policy should be implemented.

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Implied risk-neutral default probabilities via conic finance

Abstract: Despite financial modelling often takes place under risk-neutral settings where trading activities are assumed to obey the law of one price, in practice quoted market prices are direction-dependent. Nonetheless, many valuation models require input parameters, implied from observed market quotes, that are consistent with the risk-neutral paradigm. In this presentation, a methodology allowing to extract risk-neutral quantities directly from bid and ask quotes, without relying on mid-quote approximations, is presented. The approach outlined relies on some monotonicity- and liquidity-related assumptions and is based on the conic finance framework, which enables to calculate bid and ask prices of financial securities by employing Choquet expectations with respect to distorted versions of the relevant pricing measures as valuation functionals. In particular, as far as the credit default swap market is concerned, it will be shown how to compute risk-neutral default probabilities from quoted bid and ask premia under well-known dynamics, and at the same time how to calculate the implied liquidity level of the market.

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Nonzero-sum stochastic impulse games with an application in competitive retail energy markets

Abstract: We study a nonzero-sum stochastic differential game with both players adopting impulse controls, on a finite time horizon. The objective of each player is to maximize her total expected discounted profits. The resolution methodology relies on the connection between Nash equilibrium and the corresponding system of quasi-variational inequalities (QVIs in short). We prove, by means of the weak dynamic programming principle for the stochastic differential game, that the value function of each player is a constrained viscosity solution to the associated QVIs system in the class of linear growth functions. We also introduce a family of value functions converging to our value function of each player, and which is characterized as the unique constrained viscosity solutions of an approximation of our QVIs system. This convergence result is useful for numerical purpose. We apply a probabilistic numerical scheme which approximates the solution of the QVIs system to the case of the competition between two electricity retailers. We show how our model reproduces the qualitative behaviour of electricity retail competition.

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Lévy Process Pinned at Random Time for Modelling of Financial Information

Abstract: The main purpose of this talk is to extend the information-based approach of Bedini-Buckdahn-Engelbert to a more general set-up. Instead of using only a Brownian bridge as an information process, we consider another important type of information processes. To model the flow of information concerning the time of bankruptcy of a company (or a state) arriving on the market, we introduce a class of processes called Lévy processes pinned at random time, generalising the Brownian bridge and gamma bridge information processes. Our first goal is to rigorously define a Lévy process pinned at random time. Our second task is to establish the Markov property with respect to its completed natural filtration and thus with respect to the usual augmentation of the latter. The resulting conclusion is the right-continuity of completed natural filtration. Certain examples of such a process are considered.

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The fractional stochastic heat equation driven by time-space Brownian motion

Abstract: We study the stochastic time-fractional stochastic heat equation driven by time-space white noise $W(t,x)$, where the space dimension of x is denoted by d. The time-fractional derivative is the Caputo derivative of order $\alpha \in (0,2)$.

- In the classical case, when $\alpha = 1$, this equation models the normal diffusion of heat in a random or noisy medium, the noise being represented by the time-space white noise $W(t,x)$.
- When $\alpha > 1$ the equation models superdiffusion or enhanced diffusion, where the particles spread faster than in regular diffusion. This occurs for example in some biological systems.
- When $\alpha < 1$ the equation models subdiffusion, in which travel times of the particles are longer than in the standard case. Such situation may occur in transport systems.

We consider the equation in the sense of distribution, and we find an explicit expression for the S'-valued solution $Y(t,x)$, where S' is the space of tempered distributions. Following the terminology of Yaozhong Hu, we say that the solution is mild if $Y(t,x) \in L^2(P)$ for all $t \in [0,\infty), x \in \mathbb{R}^d$. It is well-known that in the classical case with $\alpha = 1$, the solution is mild if and only if the space dimension $d = 1$. We prove that if $\alpha > 1$ the solution is mild both for $d = 1$ and for $d = 2$. We also give results in the case $\alpha < 1$.

The presentation is based on joint work in progress with Bernt Oksendal, University of Oslo, Norway.

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Fractional stochastic calculus in finance

Abstract: We discuss various models in finance based on fractional stochastic calculus.

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Machine learning applied to the stochastic filtering problem

Abstract: In this talk I will present a recently published work on the combination of the PDE method (also known as the splitting-up method) for solving the stochastic filtering problem and a deep learning method to represent the solution of the PDE involved. Our approach follows a recent stream of research into deep learning based approximations of PDEs which is mainly focused on high dimensional problems and related works within the context of stochastic optimal control. We illustrate our procedure by numerically solving the Kalman (linear) and Benes (nonlinear) problems.

This is a joint work with Alexander Lobbe (University of Oslo, Imperial College) and Dan Crisan (Imperial College).

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RBSDEs with optional barriers: monotone approximation

Abstract: In this talk we consider reflected backward stochastic differential equations (RBSDEs) with a Lipschitz driver and barrier processes that are optional and right lower semicontinuous. In this case, the barrier is represented as a nondecreasing limit of right continuous with left limit (RCLL) barriers. We combine some well-known existence results for RCLL barriers with comparison arguments for the control process to construct solutions. Finally, we highlight the connection of these RBSDEs with standard RCLL BSDEs.

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Epidemic modeling by birth-death processes with spatial scaling

Abstract: Interpretation of S, I, and R that appear in equations describing epidemics may not always be obvious. It can for instance be a matter of whether they describe the number or fraction of susceptible individuals etc. It also raises a question of the meaning of the parameters in those equations. Here is an attempt to give a hopefully transparent description by considering a density dependent epidemic modeling of birth-death process type based on early works by Kurtz from the 1970s'. If the population size is not varying by time, the birth-death approach

allows ODE-approximation for large populations and diffusion approximation for semilarge populations by scaling with respect to the population size, i.e. the fractions are considered. Here assuming, somewhat unrealistic, spatial homogeneity of the population, a scaling is then instead with respect to area i.e. the number of susceptibles etc. per area is considered. This spatial scaling allows diffusion approximation for the fraction of susceptible individuals etc. for models with varying population size.

Joint work with Mohamed El Fatini, Mohammed Louriki, and Torsten Lindström.

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Linearization and a superposition principle for deterministic and stochastic nonlinear Fokker-Planck-Kolmogorov equations

Abstract: We prove a superposition principle for nonlinear Fokker-Planck-Kolmogorov equations on Eu- clidean spaces and their corresponding linearized first-order continuity equation over the space of Borel (sub-)probability measures. As a consequence, we obtain equivalence of existence and uniqueness results for these equations. Moreover, we prove an analogous result for stochastically perturbed Fokker-Planck-Kolmogorov equations. To do so, we particularly show that such stochas- tic equations for measures are, similarly to the deterministic case, intrinsically related to linearized second-order equations on the space of Borel (sub-)probability measures.

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The Boltzmann - Enskog process

Abstract: The theory of SDEs with Poisson noise is used here to identify the “Boltzmann - Enskog-Process“. Its dynamic describes the space and velocity evolution of a particle of a rarified gas which density evolves according to the Boltzmann - Enskog equation. This random dynamic is identified by a stochastic process solving a SDE, for which the corresponding Kolmogorov equation is given by the ”Boltzmann - Enskog equation“. It turns out that this is the solution of a Mc Kean-Vlasov type SDE with Poisson noise: its compensator is determined by the density solving the ”Boltzmann - Enskog equation“.

The talk is based on joint results with S. Albeverio and P. Sundar, as well as, M. Friesen and P. Sundar

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Weak Dirichlet processes with jumps and solutions of path-dependent SDEs with distributional drift

Abstract: In this talk we revisit the stochastic calculus for weak Dirichlet processes which are the natural extension of semimartingale with jumps. A weak Dirichlet process X, is the sum of a local martingale M and a martingale ortogonal process A in the sense that $[A,N] = 0$ for every continuous local martingale N. We remark that if $[A] = 0$ then X is a Dirichlet process. The notion of Dirichlet process is not very suitable in the jump case since in this case A is forced to be continuous. The notion of weak Dirichlet process is also naturally related to the one of stochasticalled controlled process (in the sense of rough paths).

In the second part of the talk we focus on the example of a solution to a path-dependent SDE with jumps and possible distributional drift.

The talk is based on a joint papers with E. Bandini (Bologna).

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Some asymptotics related to double self intersection local time of Brownian motion

Abstract: We provide a sample path estimates for the terms of the chaotic expansion of the double self intersection local time of Brownian motion in dimensions 2 and 3. In dimensions $d > 3$ the double self intersection local time of Brownian motion does not exist as a random variable but as a generalized Wiener functional. In such case it can be represented as a measure in the Wiener space. We provide some asymptotics related to such measue.

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An Application of Nonzero-Sum Stochastic Differential Games in Finance

Abstract: We develop an approach for two player constraint nonzero-sum stochastic differential game, which is modeled by a Markov regime-switching jump-diffusion process. We provide the relations between a usual stochastic optimal control setting and a Lagrangian method. In this context, we prove corresponding theorems for two different type of constraints, which lead us to find real valued and stochastic Lagrange multipliers, respectively. Then, we illustrate our results for an example of cooperation between a bank and an insurance company, which is a popular, well-known business agreement type, called Bancassurance. By using stochastic maximum principle, we investigate optimal dividend strategy for the company as a best response according to the optimal mean rate of return choice of a bank for its own cash flow and vice versa.

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Some results on noise effects in stochastic fluid models

Abstract: In this talk we will present some recent results on SPDEs of fluid type. To begin with, a general framework for solving singular nonlinear SPDEs will be introduced. Then, noise

effects will be discussed in terms of blow-up phenomena, global existence and stabilities for some equations including the stochastic magnetohydrodynamics (hence Navier-Stokes/Euler) equations and stochastic Camassa-Holm type equations. Some recent results derived in the literature are extended in a unified way.

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Mean Field Optimal Stopping

Abstract: We study the optimal stopping problem of McKean-Vlasov diffusions when the criterion is a function of the law of the stopped process. A remarkable new feature in this setting is that the stopping time also impacts the dynamics of the stopped process through the dependence of the coefficients on the law. The mean field stopping problem is introduced in weak formulation in terms of the joint marginal law of the stopped underlying process and the survival process. Using the dynamic programming approach, we provide a characterization of the value function as the unique viscosity solution of the corresponding dynamic programming equation on the Wasserstein space. Under additional smoothness condition, we provide a verification result which characterizes the nature of optimal stopping policies, highlighting the crucial need to randomized stopping. Finally, we the convergence of the the finite population multiple optimal stopping problem to the corresponding mean field optimal stopping limit. These results of propagation of chaos are proved by adapting the Barles-Souganidis monotonic scheme method to the present context.

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Mortality/Longevity Risk-Minimization with or without Securitization

Abstract: In this talk we will address the risk-minimization problem, with and without mortality securitization, á la Föllmer-Sondermann for a large class of equity-linked mortality contracts when no model for the death time is specified. This framework includes situations in which the correlation between the market model and the time of death is arbitrary general, and hence leads to the case of a market model where there are two levels of information—the public information, which is generatedby the financial assets, and a larger flow of information that contains additional knowledge about the death time of an insured. We will derive the dynamics of the value processes of the mortality/longevity securities used for the securitization, and decompose any mortality/longevity liability into the sum of orthogonal risks by means of a risk basis. Next, we will quantify, as explicitly as possible, the effect of mortality on the risk-minimizing strategy by determining the optimal strategy in the enlarged filtration in terms of strategies in the smaller filtration. We will obtain risk-minimizing strategies with insurance securitization by investing in stocks and one (or more) mortality/longevity derivatives such as longevity bonds.

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Diffusion Approximation for Transport Equations with Dissipative Drifts for Time Dependent Coefficients

Abstract: We study stochastic differential equations(SDEs) with a small perturbation parameter, in which the coefficients depend on the time. We consider the dissipative condition on the drift coefficient and the local Lipschitz condition on the drift and diffusion coefficients formulated for $0 \leq t \leq T$, where $0 < T < +\infty$ is a finite horizon time, with constants depending on T. Under the aforementioned conditions we prove the existence and uniqueness result for the perturbed SDE, also the convergence result for the solution of the perturbed system to the solution of the unperturbed system when the perturbation parameter approaches zero.We consider the application of the above-mentioned results to the Cauchy problem and the transport equations.

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Volterra sandwiched volatility models

Abstract: We introduce a new financial market model where stochastic volatility is driven by an arbitrary Hölder continuous Gaussian Volterra process. The distinguishing feature of the model is the shape of the volatility SDE which ensures the solution to be “sandwiched” between two Hölder continuous functions chosen in advance. We discuss the structure of local martingale measures on this market as well as numerical algorithms for option pricing.
