Hammamet, 16 - 20. October 2023

STOCHASTICS IN MATHEMATICAL PHYSICS AND FINANCE

LIST OF SPEAKERS AND ABSTRACTS

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Wasserstein distance in terms of the comonotonicity Copula.

Abstract: In this Talk, we represent the Wasserstein metric of order p, where $p \in [1, \infty)$, in terms of the comonotonicity copula, for the case of probability measures on $\mathbb{R}^d$, by revisiting existing results. We investigate in this work the link between the Wasserstein metric of order p, where $p \in [1, \infty)$ and Copula.

In 1974, Vallender established the link between the 1-Wasserstein metric and the corresponding distribution functions for $d = 1$. In 1956, Giorgio dall'Aglio showed that the p-Wasserstein metric in $d = 1$ could be written in terms of the comonotonicity copula M without being aware of the concept of copulas or Wasserstein metrics. In talk, we show how the p-Wasserstein metric can be written in terms of the copula M on $\mathbb{R}^d$.

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Modeling Financial Risk Contagion: An Application of the SIR Model in Banking

Abstract: This article explores the application of the Susceptible-Infectious-Recovered (SIR) epidemiological model in the context of financial risk contagion within the banking sector.

The study delves into the theoretical framework of the SIR model, its adaptation to financial systems, and its implications for risk management and regulatory policies in banking. Through simulations and empirical data analysis, the article provides insights into the dynamics of financial risk contagion.

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My friendship and scientific collaboration with Habib Ouerdiane

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Optimal Stopping Under Model Uncertainty in a General Setting

Abstract: We consider the optimal stopping time problem under model uncertainty

$$R(v) = \sup_{\mathbb{P}\in\mathscr{P}} \sup_{\tau\in\mathscr{S}_v} E^{\mathbb{P}}[Y(\tau)|\mathscr{F}_v],$$

for every stopping time v, set in the framework of families of random variables indexed by stopping times. This setting is more general than the classical setup of stochastic processes, and particularly allows for general payoff processes that are not necessarily right-continuous. Under weaker integrability, and regularity assumptions on the reward family $Y = (Y(v), v \in \mathscr{S})$, we show the existence of an optimal stopping time. We then proceed to find sufficient conditions for the existence of an optimal model. For this purpose, we present a "universal" Doob-Meyer-Mertens's decomposition for the Snell envelope family R associated with Y in the sense that it holds simultaneously for all $\mathbb{P} \in \mathscr{P}$. This decomposition is then employed to prove the existence of an optimal probability model and study its properties.

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Local asymptotic properties for the growth rate of a jump-type CIR process

Abstract: We consider a one-dimensional jump-type Cox-Ingersoll-Ross process driven by a Brownian motion and a subordinator, whose growth rate is an unknown parameter. Considering the process observed continuously or discretely at high frequency, we derive the local asymptotic properties for the growth rate in both ergodic and non-ergodic cases. Local asymptotic normality (LAN) is proved in the subcritical case, local asymptotic quadraticity (LAQ) is derived in the critical case, and local asymptotic mixed normality (LAMN) is shown in the supercritical case. To obtain these results, techniques of Malliavin calculus and a subtle analysis on the jump structure of the subordinator involving the amplitude of jumps and number of jumps are essentially used.

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Mosco-Kuwae-Shioya of Dirichlet Forms on White Noise Spaces

Abstract: White Noise Analysis and Dirichlet Forms are well-established theories. In this talk we show in which way Hida convergence is related to the Mosco convergence of the gradient Dirichlet forms wrt. a sequence of Hida measures. As an example we will sketch the case of the planar polymer measure.

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Comparison Principles for stochastic Volterra equations

Abstract: Motivated by rough volatility models in mathematical finance, stochastic Volterra equations with fractional kernel have received a great deal of study in recent years. However, they fall neither into the class of semimartingales nor the class of Markov processes. Therefore, the classical framework as the

Ito formula or classical semigroup theory is not applicable which complicates their study significantly. In this talk, we are concerned with "Comparison Principles" for stochastic Volterra equations. That is, given some dominance assumption on the initial data this dominance holds pathwise almost surely for the solutions of the stochastic Volterra equation. We prove this under different assumptions on the kernel and the coefficients.

This is joint work in progress with Martin Friesen.

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Global universal approximation of functional input maps on weighted spaces

Abstract: We introduce so-called functional input neural networks defined on a possibly infinite dimensional weighted space with values also in a possibly infinite dimensional output space. To this end, we use an additive family as hidden layer maps and a non-linear activation function applied to each hidden layer. Relying on Stone-Weierstrass theorems on weighted spaces, we can prove a global universal approximation result for generalizations of continuous functions going beyond the usual approximation on compact sets. This then applies in particular to approximation of (non-anticipative) path space functionals via functional input neural networks. As a further application of the weighted Stone-Weierstrass theorem we prove a global universal approximation result for linear functions of the signature of (rough) paths.

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Learning Optimal Investment Strategy with Transaction Costs via a Randomized Dynkin Game

Abstract: We develop a reinforcement learning method to learn the optimal trading strategy in the presence of transaction costs. Using the connection between singular control and a Dynkin game for portfolio choice with transaction costs, we solve the problem by learning the value function and optimal strategy of a randomized Dynkin game, where a regularization term is incorporated to encourage exploration. We present some theoretical results and design a reinforcement learning algorithm. Numerical results are presented to demonstrated the efficiency of the algorithm.

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Green Measures for (Non) Markov Processes with Nonlocal Jump Generator

Abstract:
I this talk we consider $X(t)$, $t \geq 0$, to be a time-homogeneous Markov process in $\mathbb{R}^d$ starting from $x \in \mathbb{R}^d$. For a certain class of functions $f : \mathbb{R}^d \to \mathbb{R}$ we define

$$V(f,x) := \int_0^\infty \mathbb{E}^x[f(X(t)]\,\mathrm{d}t.$$

If this quantity exists, then $V(f,x)$ is called the *potential* for the function f. The existence of the potential $V(f,x)$ is a difficult question, and the class of admissible f shall be analyzed separately for each process

X. We are interested in the following representation of $V(f,x)$

$$V(f,x) = \int_{\mathbb{R}^d} f(y)\mathscr{G}(x,\mathrm{d}y),$$

where $\mathscr{G}(x,dy)$ is a Radon measure on $\mathbb{R}^d$. The measure $\mathscr{G}(x,dy)$ may be called the Green measure of X. We provide some examples not necessary Markov and compute explicitly the corresponding $\mathscr{G}(x,\mathrm{d}y)$. We also consider the random potential of f defined by

$$V(x,f,w) = \int_0^\infty f(X(t,w))\,\mathrm{d}t$$

and investigate the same type of question, that is,

$$V(x,f,w) = \int_{\mathbb{R}^d} f(y)\mathscr{G}(x,\mathrm{d}y,w),$$

where $\mathscr{G}(x,\mathrm{d}y,w)$ is the random Green measure of $X(t)$, that is, a random Radon measure on $\mathbb{R}^d$. Finally, we show the existence of Green measures for Markov processes with a nonlocal jump generator without second moment and a suitable condition on its Fourier transform. This talk is based, in particular, on the joint works [2, 1, 3].

References

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Some topics related with regime-switching in Finance, Insurance and Energy

Abstract: First, we will focus upon the valuation of energy quanto options in a regime-switching framework with stochastic interest rates. Using change of measure and fast Fourier transform techniques, we obtain pricing formulae for energy quanto options on futures. We show the precision of our pricing formula on a quanto option written on temperature and electricity future prices.

Next, we will investigate death-linked contingent claims (GMDBs) paying a random financial return at a random time of death in the general case where financial returns follow a regime switching model with two-sided phase-type jumps. We approximate the distribution of the remaining lifetime by either a series of Erlang distributions or a Laguerre series expansion. More precisely, we develop a Laurent series expansion of the discounted Laplace transform of the subordinated process at an Erlang distributed time, which leads to explicit formulae for European-type GMDB. We further concentrate upon path-dependent GMDBs with lookback features, by relying on a Sylvester equation approach.

This is joint work with Fred Benth, Peter Hieber, Sinem Kozpinar.

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Neural SDEs for Conditional Time Series Generation using the Signature-Wasserstein-1 metric

Abstract: (Conditional) Generative Adversarial Networks (GANs) have found great success in recent years, due to their ability to approximate (conditional) distributions over extremely high dimensional spaces. However, they are highly unstable and computationally expensive to train, especially in the time series setting. Recently, it has been proposed the use of a key object in rough path theory, called the signature of a path, which is able to convert the min-max formulation given by the (conditional) GAN framework into a classical minimization problem. However, this method is extremely expensive in terms of memory cost, sometimes even becoming prohibitive. To overcome this, we propose the use of Conditional Neural Stochastic Differential Equations, which can be designed to have a constant memory cost as a function of depth, being more memory efficient than traditional deep learning architectures. We empirically test that this proposed model is more efficient than other classical approaches, both in terms of memory cost and computational time, and that it usually outperforms them according to several metrics.

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Optimal control for Volterra dynamics

Abstract: We study a stochastic control problem for a Volterra-type controlled forward equation with past dependence obtained via convolution with a deterministic kernel. To be able to apply dynamic programming to solve the problem, we lift it to infinite dimensions and we formulate a UMD Banach-valued Markovian problem, which is shown to be equivalent to the original finite-dimensional non-Markovian one. We characterize the optimal control for the infinite dimensional problem and show that this also characterizes the optimal control for the finite dimensional problem.

The presentation is based on joint work with Michele Giordano (University of Oslo and Statkraft.)

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On the asymptotic outcomes of generative AI

Abstract: Starting from a simple deterministic model, we show that the asymptotic outcomes of both shallow and deep neural networks such as those used in BloombergGPT to generate economic time series are exactly the Nash equilibria of a non-potential game. We then analyze deep neural network algorithms that converge to these equilibria. The approach is extended to federated deep neural networks between clusters of regional servers and on-device clients. Finally, the variational inequalities behind large language models including encoder-decoder related transformers are established.

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A subdiffusive stochastic volatility jump model

Abstract: Subdiffusions appear as good candidates for modeling illiquidity in financial markets. Existing subdiffusive models of asset prices are indeed able to capture the motionless periods in the quotes of thinly-traded assets. However, they fail at reproducing simultaneously the jumps and the time-varying random volatility observed in the price of these assets. The aim of this work is hence to propose a new model of subdiffusive asset prices reproducing the main characteristics exhibited in illiquid markets. This is done by considering a stochastic volatility jump model, time-changed by an inverse subordinator. We derive the forward fractional partial differential equations (PDE) governing the probability density function of the introduced model and we prove that it leads to an arbitrage-free and incomplete market.

By proposing a new procedure for estimating the model parameters and using a series expansion for solving numerically the obtained fractional PDE, we are able to price various European-type derivatives on illiquid assets and to depart from the common Markovian valuation setup. This way, we show that the introduced subdiffusive stochastic volatility jump model yields consistent and more reliable results in illiquid markets.

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Ergodicity of stochastic Volterra processes

Abstract: We study limit distributions, stationary processes, and ergodicity for stochastic Volterra processes. Firstly, we prove the existence of limit distributions and stationary processes for affine Volterra processes on $\mathbb{R}_+^m$ obtained from

$$X_t = x_0 + \int_0^t k(t-s)(b+\beta X_s)ds + \int_0^t k(t-s)\sigma(X_s)dB_s$$

where $\sigma(x) = \mathrm{diag}(\sigma_1\sqrt{x_1}, \dots, \sigma_m\sqrt{x_m})$. Although the process is non-markovian, it turns out that the limit distribution is independent of the initial state x_0 if and only if $k \notin L^1(\mathbb{R}_+)$. As an application, we study ergodicity, law-of-large numbers, and the maximum-likelihood estimation of the drift parameters.

Afterwards, we study stochastic Volterra processes on Hilbert space H obtained from

$$u(t) = g(t) + \int_0^t k(t-s)(Au(s) + F(u(s))ds + \int_0^t h(t-s)\sigma(u(s))dW_s$$

where $(A, D(A))$ is a closed and densely defined linear operator and $(W_t)_{t\geq 0}$ is a cylindrical Wiener process. Solutions are obtained from an analogue of the classical "mild formulation" for markovian SPDEs. We prove that, under natural conditions, the unique mild solution satisfies $u(t) \longrightarrow \pi_g$ in the Wasserstein distance, and that the limit distribution π_g is independent of g if and only if $k \notin L^1(\mathbb{R}_+)$. For $k \in L^1(\mathbb{R}_+)$ it is shown that π_g is parameterised by the limit $g(\infty) = \lim_{t\to\infty} g(t)$.

This talk is based on several (ongoing) works with Mohamed Ben Alaya, Luigi Amadeo Bianchi, Stefano Bonaccorsi and Pen Jin.

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An improved characterization theorem - its interpretation in terms of Mallivain calculus and applications to SPDEs

Abstract: We consider spaces of test and regular generalised functions of white noise. These spaces 20 years ago were characterized by holomorphy on infinite dimensional spaces together with an integrability condition. We, instead, give a characterisation in terms of U-functionals, i.e., classic holomorphic functions on the one dimensional field of complex numbers, together with the same integrability condition.

The characterisation of regular generalised functions is useful for solving singular SPDEs. Whereas, the characterisation of test functions is useful for showing smoothness of solutions to SPDEs in the sense of Mallivain calculus. We present concrete examples confirming the usefulness in both cases.

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Strong solutions to McKean-Vlasov SDEs with coefficients of Nemytskii-type

Abstract: We study a large class of McKean–Vlasov SDEs with drift and diffusion coefficient depending on the density of the solution‘s time marginal laws in a Nemytskii-type of way. A McKean–Vlasov SDE of this kind arises from the study of the associated nonlinear FPKE, for which is known that there exists a bounded Sobolev-regular Schwartz-distributional solution u. Via the superposition principle, it is already known that there exists a weak solution to the McKean–Vlasov SDE with time marginal densities u. We show that there exists a strong solution the McKean–Vlasov SDE, which is unique among weak solutions with time marginal densities u. The main tool is a restricted Yamada–Watanabe theorem for SDEs, which is obtained by an observation in the proof of the classical Yamada–Watanabe theorem.

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Hawkes processes and Malliavin calculus for risk quantification

Abstract: In this talk, we provide an expansion formula for the valuation of financial or (re)insurance contracts (such that Stop-Loss contracts or CDO) whose payoff depends on a cumulative loss indexed by a Hawkes process, modeling self-excitation and contagion features. The methodology relies on the Poisson imbedding representation and Malliavin calculus. The expansion formula involves the addition of jumps at deterministic times to the Hawkes process in the spirit of the integration by parts formula for Poisson functional. As an extension, we indicate how this methodology can be used to provide new results on Hawkes processes (Berry Essen bounds, explicit pseudo chaotic expansion and correlations...).

This talk is based on joint works with Anthony Réveillac and Mathieu Rosenbaum.

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Geometric properties of some rough curves via dynamical systems: SBR measure, local time and Bernoulli convolutions

Abstract: We investigate geometric properties of graphs of Takagi type functions, represented by series based on smooth functions. They are Hölder continuous, and can be embedded into smooth dynamical

systems, where their graphs emerge as pullback attractors. It turns out that occupation measures and Sinai-Bowen-Ruelle (SBR) measures on their stable manifolds are dual by time reversal. A suitable version of approximate self similarity for deterministic functions allows to ”telescope” small scale properties from macroscopic ones. As one consequence, absolute continuity of the SBR measure is seen to be dual to the existence of local time. The investigation of questions of smoothness both for SBR as for occupation measures surprisingly leads us to the Rademacher version of Malliavin’s calculus, and Bernoulli convolutions. The link between the rough curves considered and smooth dynamical systems can be generalized in various ways. Applications to regularization of singular ODE by rough signals are on our agenda.

This is joint work with O. Pamen (U Liverpool and AIMS Ghana).

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Dynamic minimisation of the commute time for a diffusion

Abstract: Motivated in part by a problem in simulated tempering (a form of Markov chain Monte Carlo) we seek to minimise, in a suitable sense, the time it takes a (regular) diffusion with instantaneous reflection at 0 and 1 to travel to 1 and then return to the origin (the so-called commute time from 0 to 1).

We consider a dynamic version of this problem where the control mechanism is related to the diffusion’s drift via the corresponding scale function. We are only able to choose the drift at each point at the time of first visiting that point and the drift is constrained on a set of the form $[0,\ell) \cup (i,1]$. This leads to a type of stochastic control problem with infinite dimensional state.

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Approximation of reflected SDEs in non-smooth time-dependent domains and application to fully nonlinear PDEs with Neumann boundary condition on time-dependent domains

Abstract: We consider a class of reflected SDEs in non-smooth time-dependent domains with time sections that are increasing with time. We provide a strong approximation for this type of equations using a sequence of standard SDEs. As a consequence, we obtain an approximation scheme for the associated generalized BSDEs in this markovian setting using standard BSDEs. As a by-product, we get an approximation by a sequence of standard PDEs for the solution of a system of PDEs with nonlinear boundary conditions on time-dependent domains.

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Classical and Quantum Continuity Equations in White Noise Theory

Abstract: In this talk, we discuss the continuity equations for white noise functionals and for white noise operators. By applying the quantum decomposition of white noise functionals, the continuity equations of white noise functionals are reformulated as the evolution systems for white noise functionals. Then by applying canonical topological isomorphisms for white noise operators and (classical) continuity equations for white noise functionals, we formulate the quantum continuity equations for white noise

operators. By studying the classical and quantum evolution systems, we discuss the solutions of classical and quantum continuity equations.

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Recent advances in modeling and efficient estimation of MVA

Abstract: In recent decades, the pricing and riskmanagement of financial derivatives has seen a major change due to the different valuation adjustments that have been introduced (CVA, KVA and MVA). In this talk, after providing a brief introduction of this field, an efficient numerical scheme based on the concept of static replication will be presented. The impact of some model limitations will be outlined and important open problems for future research will be discussed.

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Modeling renewable energy markets with positive CARMA

Abstract: In this presentation, we investigate the application of Continuous-Time Autoregressive Moving Average (CARMA) processes to model dynamic aspects of renewable energy markets. Our analysis focuses primarily on the modeling of electricity forward prices and wind power generation levels. Specifically, we explore the mathematical conditions necessary for CARMA models to yield positive values, an essential criterion for accurately simulating market variables such as forward electricity prices or wind speeds.

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An infinite-dimensional affine stochastic volatility model

Abstract: We introduce a flexible and tractable infinite-dimensional stochastic volatility model. More specifically, we consider a Hilbert space valued Ornstein–Uhlenbeck-type process, whose instantaneous covariance is given by a pure-jump stochastic process taking values in the cone of positive self-adjoint Hilbert–Schmidt operators. The tractability of our model lies in the fact that the two processes involved are jointly affine, that is, we show that their characteristic function can be given explicitly in terms of the solutions to a set of generalized Riccati equations. The flexibility lies in the fact that we allow multiple modeling options for the instantaneous covariance process, including state-dependent jump intensity. Infinite dimensional volatility models arise, for example, when considering the dynamics of forward rate functions in the Heath–Jarrow–Morton–Musiela (HJMM) modeling framework using the Filipović space. In this setting, we discuss various examples: an infinite-dimensional version of the Barndorf–Nielsen–Shephard stochastic volatility model, as well as covariance processes with a state dependent intensity.

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Consumption with Stochastic Investment Opportunities

Abstract: In this talk we consider an optimal consumption-investment problem where the risky assets follow an n-dimensional diffusion process whose coefficients are driven by a separate k-dimensional diffusion. This general framework encompasses many classical models wherein parameters of the market model such as the interest rate or volatility are taken to be stochastic processes. In the incomplete market case the resulting Hamilton-Jacobi-Bellman (HJB) equation is a high dimensional non linear PDE and thus not amenable to direct analysis. The aim of this work is to provide an alternative method to study the solution of the HJB equation. In this talk we focus on the one dimensional complete market case and show that solving the HJB equation is equivalent to solving an associated variational problem which is more susceptible to numerical methods. Additionally we highlight how this method may be extended to tackle the incomplete market case.

This is joint work in progress with Paolo Guasoni.

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Large deviation principle in infinite dimensional space

Abstract: We consider a positive distribution Φ which defines a probability measure $\mu = \mu_\Phi$ on X' the dual of some real nuclear Fréchet space. We consider the family $\{\mu_\varepsilon, \varepsilon > 0\}$, where μ_ε denotes the image measure of μ by the measurable map on X' given by $g_\varepsilon(\lambda) = a(\varepsilon)\lambda, \quad \forall\lambda \in X'$,where a is real positive valued function on $\mathbb{R}$. A large deviation principle is proved for the family $\{\mu_\varepsilon, \varepsilon > 0\}$, and application to stochastic differential equation is given.

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Deep Backward Schemes for High-Dimensional Portfolio Optimization Problem

Abstract: In this presentation, we consider the problem of portfolio choice for an investor who wants to maximize the utility of his final wealth. We provide a numerical scheme based on neural networks and a discretization of a backward stochastic differential equation associated with the original problem. In the first part we present the model and we explain the link to a semi-linear PDE. Then, we prove the convergence of the numerical scheme. Finally, we provide some numerical results.

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Optimal control of SPDEs driven by time-space Brownian motion

Abstract: In this paper, we study a Pontryagin type stochastic maximum principle for the optimal control of a system, where the state dynamics satisfy a stochastic partial differential equation (SPDE) driven by a two-parameter (time-space) Brownian motion (also called Brownian sheet). We first discuss some properties of a Brownian sheet driven linear SPDE which models the growth of an ecosystem.

Associated to the maximum principle there is an adjoint process represented by a linear backward stochastic partial differential equation (BSPDE) in the plane driven by the Brownian sheet. We give a closed solution formula for general linear BSPDEs in the plane and also for the particular type coming from the adjoint equation. Further, applying time-space white noise calculus we derive sufficient conditions and necessary conditions of optimality of the control. Finally, we illustrate our results by solving a linear quadratic control problem and an optimal harvesting problem in the plane. We also study possible applications to machine learning.

The presentation is based on joint work with Nacira Agram (KTH), Frank Proske (UiO) and Olena Tymoshenko (UiO).

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Time discretizations for the nonlinear filtering problem

Abstract: The solution of the continuous time filtering problem can be represented as a ratio of two expectations of certain functionals of the signal process that are parametrized by the observation path. In this talk, I will introduce a class of discretization schemes for these functionals of arbitrary order and show its robustness in the sense of Clark. This is a joint work with Dan Crisan (Imperial) and Alexander Lobbe (UiO & Imperial)

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An exploration of small jump approximation and integration by parts for exponential Lévy processes with infinite activity

Abstract: The usefulness of approximations of compensated small jumps of pure jump Lévy processes is investigated. In particular, integration by parts for Monte Carlo approximation of the sensitivity measure Delta of option prices when the stock price is an exponential Lévy process with infinite activity for which the Lévy measure is sufficiently large at zero, the compensated small jumps are replaced by a suitably scaled Brownian motion as in Asmussen and Rosinski (2001). For European-type options, the integration by parts is taken with respect to both the approximating Brownian motion and the remaining jumps following the approach of Bally, Bavouzet, and Messaoud (2007), here with the two types of integration by parts weighted in a reasonable manner.

Simulations indicate that compensated small jump approximation by a suitably scaled Brownian motion works well considering just option prices of an exponential Lévy process model. However, simulations for the normal inverse Gaussian situation indicate that the application of integration by parts of sensitivity should be used by care. For a numerical approximation of the Delta sensitivity, in the case of vanilla for which sample estimate of the classical differentiation of the pay-off is possible, a straightforward Monte Carlo approximation outperforms integration by parts while for digital type of options for which

classical differentiation of the pay-off is not possible, the integration by parts is still applicable, though not strongly performing.

The numerical findings seems to motivate an approximative jump-diffusion model (with finite jump intensity) even though the stock price itself may be described by an exponential pure-jump infinite activity Lévy process.

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Weak uniqueness for a PDE with boundary conditions

Abstract: In a previous work (Laure Coutin-Monique Pontier, 2020), it has been proved that the joint law of a diffusion and the running supremum of its first component is absolutely continuous and that its density satisfies a weak partial differential equation with boundary condition. In this work, we prove uniqueness of the solution of that PDE.

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Stackelberg games and moral hazard with constraints: a stochastic target approach

Abstract: In this talk, we provide a general approach to reformulate any stochastic Stackelberg differential games as a single-level optimisation problem with target constraint. More precisely, by considering the backward stochastic differential equation associated to the continuation utility of the follower as a controlled state variable for the leader, in the spirit of what is done in principal-agent problems, we are able to rewrite the leader's unconventional stochastic control problem as a more standard stochastic control problem, yet with stochastic target constraints. Then, using the methodology developed by Soner and Touzi (2002) or Bouchard, Élie, and Imbert (2010), the optimal strategies as well as the corresponding value of the Stackelberg equilibrium can then be obtained by solving a well-specified system of Hamilton–Jacobi–Bellman equations. We will illustrate these results through a simple example, and briefly explain how this approach can also be used in principal–agent problems to incorporate constraints on the terminal payment.

Joint work with Camilo Hernández, Nicolás Hernández Santibáñez and Emma Hubert.

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Nonlinear Fokker–Planck–Kolmogorov equations as gradient flows on the space of probability measures

Abstract: We propose a method to identify nonlinear Fokker–Planck–Kolmogorov equations (FPK equations) as gradient flows on the space of probability measures on $\mathbb{R}^d$ with a natural differential geometry. Our notion of gradient flow does not depend on any underlying metric structure such as the Wasserstein distance, but is derived from purely differential geometric principles. We explicitly identify the associated energy functions and show that these are Lyapunov functions for the FPK solutions. Our examples cover classical and generalized porous media equations, where the latter have a generalized diffusivity function and a nonlinear transport-type first-order perturbation.

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Infinite Dimensional Promenade

Abstract: In this talk, a selection of joint works with Prof. Ouerdiane will be presented in a historical chronology, somehow specific to our infinite-dimensional journey. The starting point but also the motivation will be the famous martingale representation Theorem due to Itô (1951), which generates the chaos expansion of Brownian functionals which gives rise to Fock space and then Bargaman-Segal isometry etc ...

It is while exploring these mathematical objects and concepts that we will tell a little bit about Prof. Ouerdiane's biography.

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Nonlinear Fokker-Planck-Kolmogorov equations and nonlinear Markov processes

Abstract: Since the middle of last century a substantial part of stochastic analysis has been devoted to the relationship between (parabolic) linear partial differential equations (PDEs), more precisely, linear Fokker-Planck-Kolmogorov equations (FPKEs), and stochastic differential equations (SDEs), or more generally Markov processes. Its most prominent example is the classical heat equation on one side and the Markov process given by Brownian motion on the other. This talk is about the nonlinear analogue, i.e., the relationship between nonlinear FPKEs on the analytic side and McKean-Vlasov SDEs (of Nemytskii-type), or more generally, nonlinear Markov processes in the sense of McKean on the probabilistic side. This program has been initiated by McKean already in his seminal PNAS- paper from 1966 and this talk is about recent developments in this field. Topics will include existence and uniqueness results for distributional solutions of the nonlinear FPKEs on the analytic side and equivalently existence and uniqueness results for weak solutions of the McKean-Vlasov SDEs on the probabilistic side. Furthermore, criteria for the corresponding path laws to form a nonlinear Markov process will be presented. Among the applications are e.g. porous media equations (including such with nonlocal operators replacing the Laplacian and posssibly being perturbed by a transport term) and their associated nonlinear Markov processes. But also the 2D Naiver-Stokes equation in vorticity form and its associated nonlinear Markov process will be discussed.

Joint work with: Viorel Barbu, Al.I. Cuza University and Octav Mayer Institute of Mathematics of Romanian Academy, Ia si, Romania Marco Rehmeier, Bielefeld University and SNS Pisa

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The Boltzmann processes

Abstract: Given a solution $f := f(t,x,v)$ of the Boltzmann equation we prove the existence of an associated stochastic differential equation driven by a Poisson noise that depends on f. We show that, when the distribution of the solution admits a probability density for each time t, then this coincides with f. The stochastic differential equation is hence of McKean -Vlasov type and its solution is a "Boltzman process", i.e a stochastic process which describes the dynamic in space and velocity of a tagged particle of a gas evolving with density f. We construct in this way Boltzmann processes for the Boltzmann equation with hard spheres and with hard potentials. The proof relies on first showing that any solution f of the Boltzmann equation is also the unique solution of an associated bilinear equation.

This is a joint work with S. Albeverio and P. Sundar

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Twisted Lie algebras by invertible derivation

Abstract: We introduce an algebra structure denoted by InvDer algebra whose which we twist an algebra thanks to an invertible derivation, where its inverse is also a derivation. We define InvDer Lie algebras, InvDer associated algebras, InvDer zinbiel algebras and InvDer dendriforme algebras. We also study the relations between these structures using the Rota-Baxter operators and the endomorphism operators.

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Some facts about a measure related with the generalized double intersection local time of Brownian motion

Abstract: When d is greater or equal than 4, the d-dimensional Brownian motion fails to have a "usual" square integrable double intersection local time. Instead, this double intersection local time can exist as a generalized Wiener function which can be represented by a finite measure on the classical Wiener space. We derive some properties of this measure.

This talk is based on a joint a work with A.A. Dorogovtsev.

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Robust nonparametric analysis of the term structure of volatility

Abstract: This talk presents a jump-robust nonparametric method for estimating the volatility term structure in the general term structure model of [3] along with empirical findings. The conventional belief that the term structure of bond markets could be adequately explained by a small number of linear factors has recently been called into question. In [4], it was discovered that this pattern might be artificially generated due to the substantial local correlation in yield curves. To mitigate this problem, the authors proposed i.a. an alternative approach using so-called "difference returns" which involves differencing yield curve data not only along the temporal but also the maturity dimension. It turns out that economically motivated difference returns coincide with a discretized version of semigroup adjusted increments that where derived in [1] and [2] from a statistical perspective, in the context of continuous arbitrage-free term structure dynamics. This observation allows for formal infill asymptotics for difference returns in the fully general term structure setting of [3], viewing the corresponding scaling limit as the time-varying realized volatility term structure rather than a static covariance. The presented theory can be applied in any term structure model.

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Geometric models inducing Ornstein-Uhlenbeck type phenomena

Abstract: By the mean of geometric models, we present the Airault- Malliavin-Ouerdiane approach for constructing Ornstein Uhlenbeck opera- tors as generators of stochastic ow process living in some complex domain.

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Ludwig Eduard Boltzmann and his understanding of the role of chaos in thermodynamics

Abstract: The movie maker Ralf Silberkuhl presents a movie produced together with the mathematician Barbara Rüdiger and the Choreograph Jean Laurent Sasportes. In this movie the chaotic dynamics of molekules of a gas expanding in vacuum is evidenced and measured through the choreographic movement of 4 dancer (Tsiao Ting Lee, Sophia Otto, Francesca Pavesio, Emiko Tamura) with 8 supporters, as well as classical and new music performances (by Philip Kukulies and Sebastian de Jesus Lara Franco) Some intervention by Barbara Rüdiger on the role of classical mechanics and stochastic in thermodynamics supports the mathematical and physical understanding and interpretation of the 3 choreographic scenes.

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Nonparametric Bayesian estimation with piecewise constant priors for stochastic process observations

Abstract: The main topic of the talk is a nonparametric Bayesian approach to estimation of the volatility function of a stochastic differential equation (SDE) driven by a gamma process. The volatility function is assumed to be positive and Hölder continuous. We first show that the SDE admits a weak solution under a simple growth condition, which is unique in law. In the statistical problem, the volatility function is always modelled a priori as piecewise constant on a partition of the real line, and we specify an inverse gamma prior on its coefficients. This leads to a straightforward procedure for posterior inference. We show posterior consistency and that the contraction rate of the posterior distribution depends on the Hölder exponent. Related work is on a Bayesian approach to volatility function estimation for diffusion processes and to intensity estimation for counting processes. Common features are modelling with a priori piecewise constant functions, whereas the underlying true ones are (Hölder) continuous. Moreover, the contraction rates turn out to be the same in all discussed situations.

Based on joint work with Denis Belomestny, Shota Gugushvili, Moritz Schauer and Frank van der Meulen.

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Optimal portfolio selection in the Itô-Markov market

Abstract: We study the portfolio selection problem in the Black-Scholes-Merton market with prices of financial assets described by the Itô-Markov additive processes which link together Lévy processes and regime-switching models. In this market the bank interest rate, stocks appreciation rates and volatility rates are modulated by a continuous-time Markov chain. Thus this model takes into account two sources of risks: the jump diffusion risk and the regime-switching risk. For this reason the market is incomplete. We adopt a method to complete the market based on an enlargement of the market using a set of Markovian jump securities, Markovian power-jump securities and impulse regime-switching securities. We solve the investment problem related with identifying the optimal strategy that maximizes the expected value of the logarithmic utility function of the wealth process at the end of some fixed period.

This is joint work with prof. Z. Palmowski and prof. Ł. Stettner.

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Distance between closed sets and the solutions to stochastic partial differential equations

Abstract: The goal of this presentation is to clarify when the solutions to stochastic partial differential equations stay close to a given subset of the state space for starting points which are close as well. This includes results for deterministic partial differential equations. As an example, we will consider the situation where the subset is a finite dimensional submanifold with boundary. We also discuss applications to Mathematical Finance, namely the modeling of the evolution of interest rate curves.

This presentation is based on joint work with Toshiyuki Nakayama (MUFG Bank, Tokyo, Japan).

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Real Analyticity and Signature Transforms

Abstract: Signature Transforms became an important tool for feature extraction on path spaces. We introduce real analytic maps on path spaces and show which how real analytic maps are related to signature transforms. This yields another perspective on the Hambly-Lyons Theorem. We do also analyse reproducing kernel Hilbert spaces with respect to the kernelization of signature regressions, which are also related to real analytic maps on path spaces. Both instances show the surprising importance of real analyticity in this setting.

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Mean field game of cross-holding with common noise

Abstract: We consider the mean field game modeling of optimal cross-holding within a population of investors endowed with some idiosyncratic risk process. In this talk, we consider the extension to the situation where the individual risks are correlated through some common noise. Unlike the uncorrelated case, we recover here the trade off between average returns and risks, which is the main novel difficulty to solve the problem. Our main finding is that the mean field no-arbitrage condition imposes some structure restrictions on the model, which turn out to play a crucial role. Under these conditions, we provide a quasi explicit solution for the mean field game of cross holding.

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Constrained Optimal Control Problem Applied to Vaccination for COVID-19 Epidemic

Abstract: In this talk, we present a model that describes the epidemic dynamics of Covid-19 after vaccine deployment, as an extension of the standard SEAIR model incorporating temporary protection vaccine compartment. An optimal control problem is formulated with the aim of minimizing the number of infected individuals while considering intervention costs and the constraints of the total and maximum daily vaccine administration. We use the penalty method to approximate this optimization problem and derive an optimality system that characterizes the optimal control.

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Parameter estimation for polynomial processes

Abstract: We consider parameter estimation for discretely observed generic polynomial (and in particular affine) Markov processes, relying on a quasi-likelihood approach. Specifically, we consider polynomial martingale estimating functions up to a given degree. Within this class the Heyde-optimal estimating function can be computed in closed form. This allows to derive consistency and asymptotic normality, based on results of [1] and the ergodic theory for Markov processes.

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Towards a Measurement of Cyber Pandemic Risk

Abstract: Systemic cyber risks like the 2017 WannaCry and NotPetya incidents pose a major threat to societies, governments, and businesses worldwide. For regulatory institutions, preventing cyber pandemics is thus a top-priority issue. Moreover, dealing with systemic accumulation risks is also challenging for insurance companies since risk pooling does not apply to these incidents.

Based on classical contagion models from network science and mathematical biology, we capture the spread of systemic cyber risks in a stylized fashion and identify two types of suitable controls: security- and topology-based interventions. In particular, topology-based measures are necessary to control the cyber pandemic risk exposure in large-scale systems with a more heterogeneous – and thus realistic - arrangement of network nodes. Building on this, we present the first steps towards an axiomatic approach to measuring cyber pandemic risks.

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Parameter estimation in rough Bessel model

Abstract: We construct consistent statistical estimators of the Hurst index, volatility coefficient, and drift parameter for Bessel processes driven by fractional Brownian motion with $H < 1/2$. As an auxiliary result, we also prove the continuity of the fractional Bessel process. The results are illustrated with simulations.
