Sixth Seminar on

Stochastic Analysis, Random Fields and Applications

May 19 - May 23, 2008

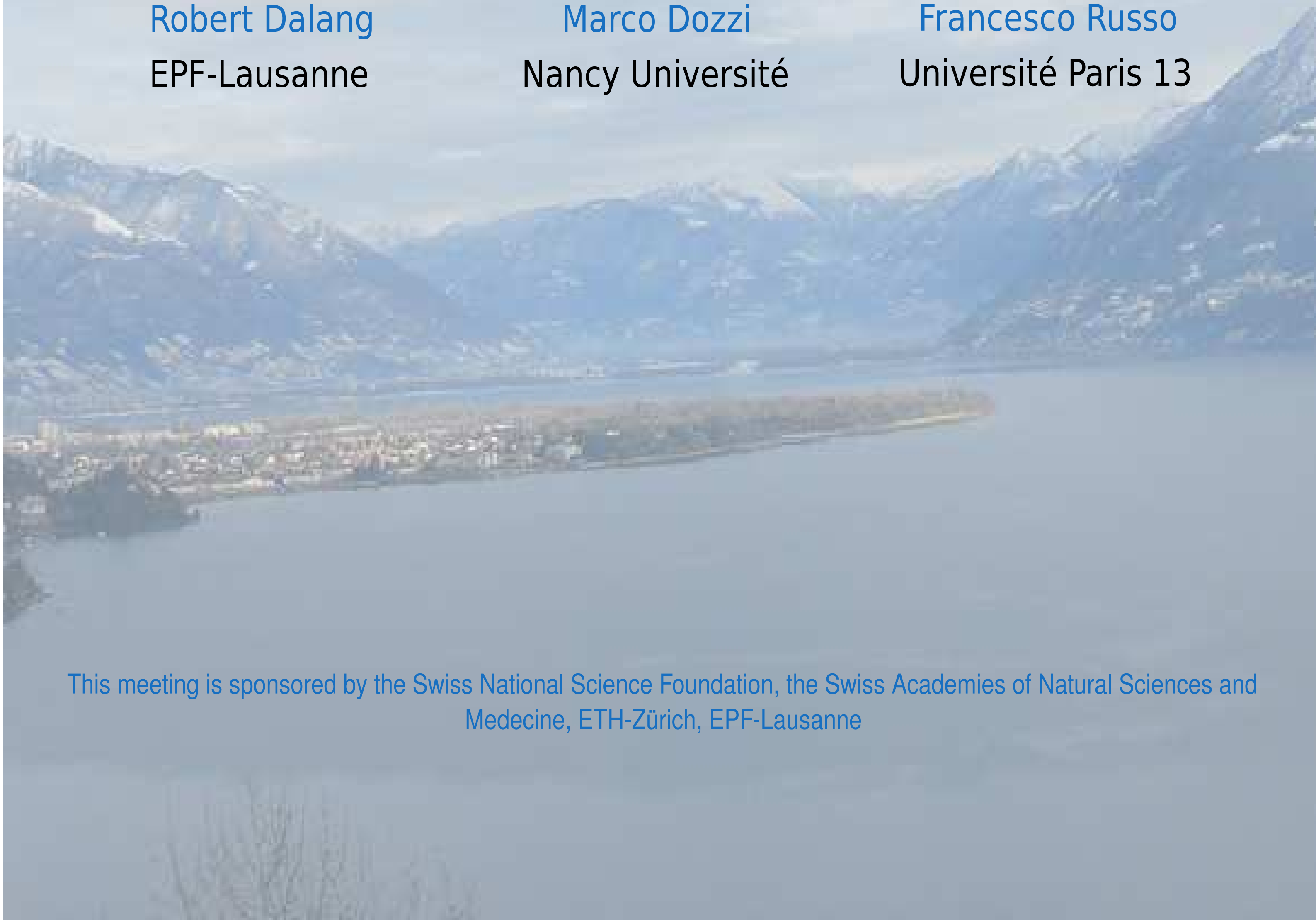
Centro Stefano Franscini, Ascona, Switzerland

Organizers

Robert Dalang
EPF-Lausanne

Marco Dozzi
Nancy Université

Francesco Russo
Université Paris 13



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15:25 - 15:50 S. DAYANIK, Princeton University
Multisource Bayesian sequential change detection

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16:20 - 16:45 G. TESSITORE, Università di Milano-Bicocca
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16:50 - 17:15 R. BUCKDAHN, Université de Bretagne Occidentale
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17:55 - 18:40 R. CARMONA, Princeton University
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16:50 - 17:15 P. VALLOIS, Université Henri Poincaré Nancy 1
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10:40 - 11:25 G. DA PRATO, Scuola Normale Superiore di Pisa
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15:25 - 15:50 N. EISENBAUM, Université de Paris VI
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17:50 - 18:15 A. GNEDIN, Utrecht University
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18:15 *End of Meeting*

ABSTRACTS

of the Sixth Seminar on

Stochastic Analysis, Random Fields and Applications

Sergio Albeverio (Universität Bonn)

Some new developments in infinite-dimensional integration and asymptotics

Hassan Allouba (Kent State University)

From BTP and Kuramoto-Sivashinsky PDEs to BTP SIE and KS SPDEs

Recently we have introduced a new large class of processes that we call Brownian-time processes (BTPs), and we connected them to new fourth order PDEs. The BTP-PDE connection is interesting in several respects. Probabilistically, it settled the open problem of linking Burdzy's IBM—a special case of BTPs—to PDEs. Also, BTP-PDEs manifest the memory preserving (non-Markovian) nature of the underlying BTP by including the Laplacian of the initial solution u_0 in the PDE itself. Analytically, the BTP-PDEs have smooth solutions for all times and all spatial dimensions $d \geq 1$ despite the presence of the "nasty" *positive* bi-Laplacian. On the other hand, by modifying the BTPs and adapting the methods connecting them to PDEs, we were able to solve a linearized version of the famous Kuramoto-Sivashinsky (KS) PDE in all spatial dimensions $d \geq 1$ using what we call the imaginary BT with Brownian angle process (IBTBAP). By the use of a Duhamel type principle, we can then treat nonlinear versions of KS and Swift-Hohenberg (SH) PDEs.

After reviewing some of these results, I will introduce and talk about BTP stochastic integral equations (SIEs):

$$U(t,x) = \int_{\mathbb{R}^d} \mathbb{K}_t^{\text{BTBM}}(x,y)u_0(y)dy + \int_{\mathbb{R}^d}\int_0^t \mathbb{K}_{t-s}^{\text{BTBM}}(x,y)a(U(s,y))\mathcal{W}(ds \times dy)$$

where the kernel $\mathbb{K}_t^{\text{BTBM}}(x,y)$ is the density of a Brownian-time Brownian motion (BTBM) and $\mathcal{W}$ is space-time white noise. It turns out that—under mild conditions on the diffusion coefficient a—there exists γ-Hölder-continuous solutions to the above BTP SIE, and that the Hölder exponent γ is dimension-dependent and $\gamma \in \left(0, \frac{4-d}{8}\right)$ for $1 \leq d \leq 3$. This is in sharp contrast to second order reaction diffusion SPDEs, whose kernel formulation may be obtained from the BTP SIE above by replacing $\mathbb{K}_t^{\text{BTBM}}(x,y)$ with the density of a BM. In that case real-valued solutions are confined to $d = 1$. The method of the proof consists of introducing Brownian-time random walks (BTRWs) on lattices and rewriting the spatially-discretized version of the BTP SIE (BTRW SIE) in terms of the density of the BTRW. We then obtain estimates on the BTRW density that we use to prove existence and regularity for the BTRW SIE as well as to prove the convergence of these discretized BTRW SIE to our BTP SIE. In conclusion, if we replace $\mathbb{K}_t^{\text{BTBM}}(x,y)$ in the BTP SIE by the kernel associated with our IBTBAP we obtain the kernel formulation of the linearized KS SPDE driven by space-time white noise. Adapting our BTP approach we get similar existence and dimension-dependent regularity for the KS and SH SPDEs in spatial dimensions $1 \leq d \leq 3$. Time permitting, I'll discuss some related ongoing research.

Elisa Alòs (Universitat Pompeu Fabra)

An extension of the Hull and White formula and applications

By means of Malliavin Calculus we see that the classical Hull and White formula for option pricing can be extended to the case where the volatility and the noise driving the stock prices are correlated and where we have jumps in the asset price dynamic model. This extension will allow us to describe the effect of correlation on option prices and to derive approximate option pricing formulas. Moreover, it provides a natural approach to deal with the short-date behavior of the implied volatility for jump-diffusion models with stochastic volatility. This theory does not require the volatility to be a diffusion or a Markov process. Moreover, with these techniques the short-time behavior of the implied volatility can be analyzed for known and new volatility models; in particular, models that reproduce short-date skews of order $O(T-t)^{\delta}$, for $\delta > 1/2$.

Vlad Bally (Université Paris Est, Marne-la-Vallée)

Integration by parts formula for localy smooth laws and applications to equations with jumps

We establish the analogues of the integration by parts formula from Malliavin calculus in an abstract framework and we use it in order to study the regularity of the law of the solution of stochastic differential equations with jumps. The specific point is that the coefficients of these equations have a discontinuity and so the Malliavin calculus for jump type processes developed by Bismut and then by Bichteler, Gravereux and Jacod does not apply in this framework. The motivation for this type for equations comes from physical models.

Ole Barndorff-Nielsen (University of Aarhus)

Turbulence stochastics

A discussion is given of the modelling, by tempo-spatial stochastic processes, of velocities in freely turbulent fluids. The processes primarily considered are stationary and of the ambit type, and these are structured so as to reflect the main stylised features of free turbulence, including Kolmogorov's phenomenological theory. The processes are not of the semimartingale type, raising the question of how to extend some of the key techniques of semimartingale theory to settings of the present kind.

Sara Biagini (Università di Pisa)

The relaxed investor and the relaxed utility maximization problem

For utility functions U finite only on the positive real line, Kramkov and Schachermayer showed that under a condition on U, the well- known Reasonable Asymptotic Elasticity, the associated utility maximization problem has a (unique) optimal solution, independently of the probabilistic model. What about the "relaxed" investor, whose utility does not satisfy RAE? This has been also addressed by Kramkov and Schachermayer, but the optimal solution is characterized only for sufficiently small initial endowments. Under a sufficient (and basically necessary) joint condition on the probabilistic model and the utility, we show by relaxation and duality techniques that the maximization problem admits solution for any initial endowment. However, a singular part may pop up, that is the optimal investment may have a component which is concentrated on a set of probability zero. This singular part may fail to be unique.

Philippe Blanchard (Universität Bielefeld)

Spectral analysis of complex networks

It is shown that random walks and spectral properties of the graph Laplacian are natural procedure to analyse and classify complex empirical networks. We explain how each graph of order N can be embedded in a Riemannian manifold of dimension $N-1$. Applications of this approach to Petersen regular graphs and to urban networks (Manhattan, Venezia) will be briefly discussed. Bird flocking is a striking example of collective animal behaviour. We will describe models of coupled dynamical systems. The networks topology is encoded in the Laplacian. Synchronization will emerge from the interplay between the spectral properties of the Laplacian and the Lyapunov spectrum of the dynamics.

Raymond Brummelhuis (University of London)

Serial dependence in financial time series

As with dependence in the static case, serial dependence in time-series cannot always be reliably quantified by linear (auto-) correlation, in particular for non-linear time-series like GARCH. For the latter, model auto-correlations of e.g. the squared series (a traditional way of exhibiting serial dependence in ARCH-models) can easily fail to exist, and sample auto-correlations, though often computed in practice, may fail to convey useful information for failing to converge to a number in the large sample limit (as shown by work of Davis, Mikosch and others). In this situation it is natural to use other risk-measures to quantify serial dependence, in particular copula-based ones which do not require moment-conditions for their existence. In this talk we will study serial dependence in ARCH-models using lower tail dependence coefficients and certain generalizations there-off. The lower tail dependence coefficient of two random variables X and Y is defined by

$$\lambda_{X|Y} = \lim_{\alpha\to 0} \mathbb{P}\left(X < q_X(\alpha) \,|\, Y < q_Y(\alpha)\right),$$

(where q_X denotes the quantile-function of X and where we assume existence of the limit) and the *generalized lower tail dependence coefficient* by

$$\lambda^{\psi}_{X|Y} = \lim_{\alpha\to 0} \mathbb{P}\left(X < q_X(\psi(\alpha)) \,|\, Y < q_Y(\alpha)\right),$$

where $\psi = \psi(\alpha)$ will typically be required to tend to 0 at a rate not faster than α: $\alpha = O(\psi(\alpha))$ as $\alpha \to 0$.

Our results will for example show that if $(X_n)_n$ is a (genuine) stationary ARCH(1), then $\lambda_{X_{n+p}|X_n} \neq 0$ for all $p \geq 0$, while it can be 0 for non-stationary ARCH(1). Furthermore, for $\psi(\alpha)$ tending to 0 sufficiently slowly (e.g. $\psi(\alpha) = \alpha^{1-\varepsilon}$ with $\varepsilon \in (0,1)$), we will have, for both stationary and non-stationary $(X_n)_n$, that $\lambda^{\psi}_{X_{n+p}|X_n} \neq 0$, with a numerical value which is in fact equal to the (unconditional) probability that $X_n < 0$, and therefore in particular independent of p.

Dependence measures like $\lambda_{X|Y}$ and $\lambda^{\psi}_{X|Y}$ are relevant for financial risk-management, where quantiles are interpreted as value-at-risk. Indeed, in a financial setting where X_n is a daily price or a return,

$$\mathbb{P}\left(X_{n+p} < q_{X_{n+p}}(\psi(\alpha)) | X_n < q_{X_n}(\alpha)\right)$$

is the conditional probability of two value-at-risk violations (at different confidence - levels if $\psi(\alpha) \neq \alpha$) which are p days apart. We will report on numerical MC studies showing that the limit, $\lambda^{\psi}_{X_{n+p}|X_n}$ well-approximates these probabilities at small but non-zero values of α like the $\alpha = 0.01$ used in risk management. We will also report on empirical estimates of these probabilities for actual financial time-series.

Rainer Buckdahn (Université de Bretagne Occidentale)

Stochastic differential games: a backward SDE approach

In this talk that is based on joint work with Li Juan (Shandong University, branch of Weihai, P.R.China), we study zero-sum two-player stochastic differential games with the help of the theory of Backward Stochastic Differential Equations (BSDEs). More precisely, we generalize the results of the pioneering work of Fleming and Souganidis (1989) by considering cost functionals defined by controlled BSDEs and by allowing the admissible control processes to depend on events occurring before the beginning of the game. This extension of the class of admissible control processes has the consequence that the cost functionals become random variables. However, by making use of a Girsanov transformation argument (combined with Kulik's transformation in the case of jumps), which, to our best knowledge, is new in this context, we prove that the upper and the lower value functions of the game remain deterministic. Apart from the fact that this extension of the class of admissible control processes is quite natural and reflects the behavior of the players who always use the maximum of available information, its combination with BSDE methods, in particular that of the notion of stochastic "backward semigroups" introduced by Peng (1997), allows then to prove a dynamic programming principle for both the upper and the lower value functions of the game in a straight-forward way. The upper and the lower value functions are then shown to be the unique viscosity solutions of the upper and the lower Hamilton-Jacobi-Bellman-Isaacs equations, respectively. For this Peng's BSDE method (1992; 1997) is extended from the framework of stochastic control theory into that of stochastic differential games.

René Carmona (Princeton University)

An infinite-dimensional stochastic analysis approach to local volatility dynamic models

The difficult problem of the characterization of arbitrage free dynamic stochastic models for equity markets was recently given a new life by the introduction of market models based on the dynamics of the local volatility surface. Typically, market models are based on Itô stochastic differential equations modeling the dynamics of a set of basic instruments including, but not limited to, the option underliers. These market models are usually recast in the framework of the HJM philosophy originally articulated for Treasury bond markets. In this talk, we present recent results on the local volatility dynamics by employing an infinite-dimensional stochastic analysis approach.

This presentation is based on a joint work with S. Nadotchiy.

René Carmona (Princeton University)

The European union emissions trading scheme: a mathematician's perspective

Some environmental economists claim that market forces can resolve externalities such as pollution and global warming. In order to weight on this debate in a scientific manner, we introduce a mathematical model for a cap-and-trade economy which captures most of the features of the European Union Emissions Trading Scheme. We complement our theoretical analysis with numerical simulation tools designed for regulators and policy makers. Choosing the example of the electricity market in Texas, we illustrate numerically the qualitative properties observed during the implementation of the first phase of the European Union cap-and-trade CO2 emissions scheme, comparing the results of cap-and-trade schemes to the Business As Usual benchmark. In particular, we confirm the presence of windfall profits criticized by the opponents of these markets. We also demonstrate the shortcomings of tax and subsidy alternatives. Finally we introduce a relative allocation scheme which despite of its ease of implementation, leads to smaller windfall profits than the standard scheme.

Claudia Ceci (Università di Chieti-Pescara)

Optimal investment problems with marked point stock dynamics

Optimal investment problems in an incomplete financial market with pure jump stock dynamics are studied. An investor with Constant Relative Risk Aversion (CRRA) preferences, including the logarithmic utility, wants to maximize her/his expected utility of terminal wealth by investing in a bond and in a risky asset. The risky asset price is modeled as a geometric marked point process, whose dynamics is driven by two independent doubly stochastic Poisson processes, describing upwards and downwards jumps. A stochastic control approach allows to provide optimal investment strategies and closed formulas for the value functions associated to the utility optimization problems. Moreover, the solution to the dual problems associated to the utility maximization problems are derived. The case when intermediate consumption is allowed is also discussed.

Sandra Cerrai (Università di Firenze)

Normal deviations from the averaged motion for some reaction-diffusion equations with fast oscillating perturbation

I will first present some results on averaging for a wide class of stochastic PDEs of reaction-diffusion type and then I will concentrate my attention on Gaussian fluctuations from the averaged motion for some simpler models.

Alexandra Chronopoulou (Purdue University)

Hurst-index estimation and reproduction property for non-Gaussian Hermite processes

We study the behavior of Hermite processes of order q with self-similarity index $H \in (1/2, 1)$. Since these processes are self-similar, have stationary increments and exhibit long-range dependence, it is of great importance to estimate the parameter H that describes their behavior. Using Wiener-Itô multiple stochastic integrals and Malliavin calculus we prove that the variations of a general Hermite process converge in $L^2(\Omega)$ to a Rosenblatt random variable, which is an element of the second Wiener chaos. Moreover, from a theoretical point of view, we study the reproduction property of Hermite processes: the terms in the Wiener chaos decomposition of the Hermite process's quadratic variation converge, after appropriate normalization, to other Hermite processes of different orders and self-similarity parameters.

This presentation is based on a joint work with Ciprian Tudor (Paris-Sorbonne) and Frederi Viens (Purdue).

Daniel Conus (Ecole Polytechnique Fédérale de Lausanne)

The non-linear stochastic wave equation in high dimensions

We propose an extension of Walsh's classical martingale measure stochastic integral that makes it possible to integrate a general class of Schwartz distributions, which contains the fundamental solution of the wave equation, even in dimensions greater than 3. This leads to a square-integrable random-field solution to the non-linear stochastic wave equation in any dimension, in the case of a driving noise that is white in time and correlated in space. In the particular case of an affine multiplicative noise, we obtain estimates on p-th moments of the solution ($p \geq 1$), and we show that the solution is Hölder continuous. The Hölder exponent we obtain is optimal.

José Manuel Corcuera (Universitat de Barcelona)

Statistics and Malliavin calculus

When we do statistics in a Wiener space, for instance when observations come from a solution of stochastic differential equation driven by a Brownian motion, Malliavin Calculus can be used to obtain expressions for the score function as a conditional expectation. These expressions can be useful to study the asymptotic behavior of the model and estimators. For instance we can derive the local asymptotic normality property. We proceed from very simple examples to more complex ones where processes under observation can have a jump component.

Michael Cranston (University of California, Irvine)

Some results on homopolymers

This talk will focus on properties of the Gibbs measure

$$\frac{dP_{\beta,t}}{dP} = \frac{\exp \beta \int_0^t \delta_0(x-s)ds}{Z_{\beta,t}},$$

where P is the measure on continuous time simple symmetric random walk on Z^d and $Z_{\beta,t}$ is the partition function. We examine the free energy, explain phase transitions and study the behavior of typical $P_{\beta,t}$ paths as $t \to \infty$ at or near the critical parameter of β for the phase transition. We also will discuss similar models in an attempt to establish universality and scaling properties of these polymer models. The talk is a review of joint work of the speaker with Hryniv, Koralov, Molchanov and Vainberg.

Ana Bela Cruzeiro (Instituto Superior Técnico, Lisbon)

Hydrodynamics, probability and the geometry of the diffeomorphisms group

We generalize Arnold's Lagrangean picture for the Euler equation on the torus to the Navier-Stokes equation by using a Brownian motion on the corresponding space of diffeomorphisms.

Giuseppe Da Prato (Scuola Normale Superiore, Pisa)

Fokker-Planck equations for stochastic PDE's

We consider a class of stochastic PDE's in a Hilbert space H. We prove, under suitable assumptions, existence and uniqueness of measure-valued solutions of these equations in a finite interval $[0, T]$. Then we prove existence and uniqueness of measure-valued solutions in the whole real line. Applications are given to reaction-diffusion equations.

Savas Dayanik (Princeton University)

Multisource Bayesian sequential change detection

Suppose that local characteristics of several independent compound Poisson and Wiener processes change suddenly and simultaneously at some unobservable disorder time. The problem is to detect the disorder time as quickly as possible after it happens and minimize the rate of false alarms at the same time. These problems arise, for example, from managing product quality in manufacturing systems and preventing the spread of infectious diseases. The promptness and accuracy of detection rules improve greatly if multiple independent information sources are available. Earlier work on sequential change detection in continuous time does not provide optimal rules for situations in which several marked count data and continuously changing signals are simultaneously observable. In this talk, optimal Bayesian sequential detection rules will be described for such problems when the marked count data is in the form of independent compound Poisson processes, and the continuously changing signals form a multi-dimensional Wiener process.

This presentation is based on a joint work with Vincent Poor and Semih Sezer.

Jean-Dominique Deuschel (Technische Universität Berlin)

Uniqueness of gradient component for non-convex gradient models

We consider a gradient interface model with interaction potential which is a non-convex perturbation of a convex potential. Using a technique for decoupling of the nearest neighboring vertices into even and odd vertices, we show at high temperature the uniqueness for the $\nabla\phi$ Gibbs measures, the strict convexity of the surface tension, scaling limits and decay of covariances. This is an extension of Funaki and Spohn's result, where the strict convexity of potential was crucial in their proof. The result could be applied for the derivation of the hydrodynamical limit for the Landau-Ginsburg model.

This presentation is based on a joint work with Codina Cotar.

Ernst Eberlein (Universität Freiburg, Germany)

Advanced credit portfolio modeling and CDO pricing

Modeling dependence is a key issue when one derives the loss distribution of a portfolio of credit instruments. We extend the factor model approach of Vasiček by using more sophisticated distributions for the factors. Completely different distributions from the class of generalized hyperbolic distributions and their limits can be chosen for the systematic and the idiosyncratic factor in this approach.

As a result an almost perfect fit to market quotes of DJ iTraxx Europe standard tranches is achieved. The correlation structure remains flat over all CDO tranches and maturities. No base correlation framework is needed.

References

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This presentation is based on a joint work with R. Frey and E. A. von Hammerstein.

Nathalie Eisenbaum (Université de Paris VI)

A Cox process involved in the Bose-Einstein condensation

The point process corresponding to the configurations of bosons in standard conditions is a Cox process driven by the square norm of a centered Gaussian process. This point process is infinitely divisible. We point out the fact that this property is preserved by the Bose-Einstein condensation phenomenon and show that the obtained point process after such a condensation occurred, is still a Cox process but driven by the square norm of a shifted Gaussian process, the shift depending on the density of the particles.

Hans-Jürgen Engelbert (Friedrich Schiller-University)

On the structure equation: The Markov case

A (locally square integrable, local) martingale X is called normal if the associated increasing process $\langle X\rangle$ is given by $\langle X\rangle_t = t,\ t \geq 0$. For its square variation process $[X]$ we then have that M with $M_t = [X]_t - t,\ t \geq 0$, is a martingale. If, moreover, X satisfies the previsible representation property (PRP) (with respect to its natural filtration) then there exists a previsible process H such that

$$M_t = \int_0^t H_u \, dX_u, \quad t \geq 0 \, .$$

This implies the stochastic equation

$$[X]_t = t + \int_0^t H_u \, dX_u, \quad t \geq 0, \quad X_0 = x_0 \in \mathbb{R} \, , \tag{1}$$

which is called Structure Equation (SE) for the (unknown) martingale X. (By definition of a solution, X and $\int_0^t H_u \, dX_u$ should be martingales.) Note that every solution X of the structure equation is a normal martingale. The study of normal martingales was motivated by the fact that some of them (Brownian motion, compensated Poisson process, ...) satisfy the so-called chaotic representation property (CRP). Both Brownian motion and compensated Poisson process satisfy the structure equation (1) (for $H \equiv 0$ and for $H \equiv 1$) and it was the hope to find more examples of martingales X satisfying CRP (or only PRP) as solutions of the structure equation (1). An important special case of the structure equation is the so-called Markov case: For a given Borel function $f : \mathbb{R} \mapsto \mathbb{R}$, we look for a martingale X such that

$$[X]_t = t + \int_0^t f(X_{u-}) \, dX_u, \quad t \geq 0, \quad X_0 = x_0 \in \mathbb{R} \, . \tag{2}$$

If $f(x) = \beta x,\ x \in \mathbb{R}$, there is a unique solution X of (2) and it is well-known that X satisfies PRP and, for $-2 \leq \beta \leq 0$, CRP (cf. M. Emery [1]). (The solutions are called Azéma martingales.) A result of P.A. Meyer [2] states that the Markov structure equation (2) always has a solution if f is *continuous*.

In the present talk, we will give a different approach to the study of the structure equation in the Markov case. We shall construct solutions in two steps by solving a stochastic equation driven by a compensated Poisson process Π followed by an appropriate time change. The first step is very closely related to the problem of solving the autonomous deterministic equation $dZ_t = -f(Z_t)\,dt$. Besides existence of solutions, we shall also discuss uniqueness in law and PRP of solutions.

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Damir Filipovic (Vienna Institute of Finance)

Dynamic CDO term structure modelling

A collateralized debt obligation (CDO) is a security backed by a pool of defaultable reference entities such as bonds, loans or credit default swaps. The reference entities form the asset side of the CDO. Traded products are notes on so-called tranches of the CDO. They have different seniorities and build the liability side of the CDO.

Quite recently there emerged several new attempts on modelling CDO losses based on the idea instead of modeling all single defaults in the asset pool (the bottom-up approach) to model the aggregated loss function on this pool directly (top-down approach). Schönbucher [3] uses a loss process which lives on a discrete grid and arrives at a multivariate forward rate setting. Bennani [1] and Sidenius et al. [4] work with a continuous loss distribution. The aim of this paper is to give a unified general approach that encompasses the above mentioned.

We fix a filtered probability space $(\Omega, \mathcal{F}, (\mathcal{F}_t), \mathbb{Q})$, where we assume that $\mathbb{Q}$ is a risk-neutral pricing measure. Let r_t denote the continuous adapted short rate process.

Consider a CDO with an overall nominal normalized to 1, and let $\mathcal{I} \subset [0,1]$ denote the set of all attainable loss fractions, i.e. $x \in \mathcal{I}$ represents the state where $100x\%$ of the overall nominal has defaulted. Throughout, we assume that either $\mathcal{I}$ is finite with $0, 1 \in \mathcal{I}$, or $\mathcal{I} = [0,1]$, endowed with the respective topologies.

We denote by L_t the $\mathcal{I}$-valued adapted càdlàg increasing loss process with $L_0 = 0$. We assume that, for all $x \in \mathcal{I}$, there exists some predictable process $\lambda(t,x)$ such that

$$1_{\{L_t \leq x\}} + \int_0^t 1_{\{L_s \leq x\}} \lambda(s,x) ds$$

is a martingale.

The basic instrument is a (T,x)-*bond* which pays $1_{\{L_T \le x\}}$ at maturity T, for $x \in \mathcal{I}$ and $T \ge 0$. Its price at time $t \le T$ is given by risk-neutral expectation

$$P(t,T,x) = \mathbb{E}\left[e^{-\int_t^T r_s ds} 1_{\{L_T \le x\}} \mid \mathcal{F}_t\right]. \tag{1}$$

Obviously, $P(t,T,x)$ is increasing in x and decreasing in T.

Since $L_t \le 1$, the risk free T-*bond* price $P(t,T)$ at time $t \le T$ satisfies

$$P(t,T) = P(t,T,1) = \mathbb{E}\left[e^{-\int_t^T r_s ds} \mid \mathcal{F}_t\right].$$

The (T,x)-bonds are the fundamental components for the pricing of European style options. Indeed, consider any continent claim with payoff

$$F(L_T) = F(1) - \int_{\mathcal{I}} F'(y) 1_{\{L_T \le y\}}\, dy$$

at maturity T, for some bounded measurable derivative F'. Its price at time $t \le T$ is then given as linear combination of (T,x)-bonds

$$\mathbb{E}\left[e^{-\int_t^T r_s ds} F(L_T) \mid \mathcal{F}_t\right] = F(1)P(t,T) - \int_{\mathcal{I}} F'(y) P(t,T,y)\, dy.$$

Example 1. The basic components of a credit default swap are put options with payoff $(K - L_T)^+ = \int_0^K 1_{\{L_T \le y\}}\, dy$.

The ultimate goal is to provide a term structure model of Heath-Jarrow-Morton [2] type for $P(t,T,x)$. That is, we give necessary and sufficient conditions such that

$$P(t,T,x) = 1_{\{L_t \le x\}} \exp\left(-\int_t^T (f(t,u) + \phi(t,u,x))du\right) \tag{2}$$

for some Itô processes

$$f(t,T) = f(0,T) + \int_0^t a(s,T)ds + \int_0^t b(s,T)^\top \cdot dW_s \tag{3}$$

$$\phi(t,T,x) = \phi(0,T,x) + \int_0^t \alpha(s,T,x)ds + \int_0^t \beta(s,T,x)^\top \cdot dW_s. \tag{4}$$

Here W denotes some (multi-dimensional) Brownian motion, and $a(t,T)$, $b(t,T)$, $\alpha(t,T,x)$, $\beta(t,T,x)$ satisfy the appropriate regularity conditions such that the following formal manipulations and statements are meaningful. In particular, $\phi(t,T,x)$ is decreasing in $x \in \mathcal{I}$ with $\phi(t,T,1) = 0$.

Theorem 2. *If $P(t,T,x)$ can be represented of the form* (2) *then necessarily,*

$$r_t = f(t,t), \tag{5}$$

$$a(t,T) = b(t,T)^\top \cdot \int_t^T b(t,u)du, \tag{6}$$

and on $\{L_t \leq x\}$

$$\lambda(t,x) = \phi(t,t,x), \tag{7}$$

$$\alpha(t,T,x) = b(t,T)^\top \cdot \int_t^T \beta(t,u,x)du + \beta(t,T,x)^\top \cdot \int_t^T (b(t,u) + \beta(t,u,x))du. \tag{8}$$

The more interesting part for applications is the converse of Theorem 2.

Theorem 3. *Suppose that* $\Omega = \Omega_1 \times \Omega_2$*,* $\mathcal{F} = \mathcal{G} \otimes \mathcal{H}$*,* $\mathcal{F}_t = \mathcal{G}_t \otimes \mathcal{H}_t$*, and* $\mathbb{Q}(d\omega_1, d\omega_2) = \mathbb{Q}_1(d\omega_1)\mathbb{Q}_2(\omega_1, d\omega_2)$*, where*

(i) $(\Omega_1, \mathcal{G}, (\mathcal{G}_t), \mathbb{Q}_1)$ *is a filtered probability space,*

(ii) $(\Omega_2, \mathcal{H})$ *is the canonical space of càdlàg paths from* $\mathbb{R}_+$ *to* $\mathcal{I}$*, and*

(iii) $\mathbb{Q}_2$ *is a probability kernel from* Ω_1 *to* $\mathcal{H}$ *to be determined by* $\lambda(t,x)$*.*

Then any exogenous specification of $b(t,T)$ *and* $\beta(t,T,x)$ *induces some loss process* L_t *such that the bonds defined via* (2)–(8) *are arbitrage-free, that is, satisfy relation* (1)*.*

Finally, we provide an affine specification of the above generic model, which allows for efficient computation of CDO derivatives such as credit default swaps.

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This presentation is based on a joint work with Ludger Overbeck (Universität Giessen) and Thorsten Schmidt (Universität Leipzig).

Alexander V. Gnedin (Utrecht University)

On the asymptotics of exchangeable coalescents

A Λ-coalescent is a process of random coagulation in which the particles merge by collision, and the collision rates within a finite collection of particles only depend on the number of particles to collide. The rates are representable as moments of a probability measure Λ. Under certain assumptions on Λ, we discuss limit theorems for the total number of collisions in the process which starts with a given number of particles and terminates as all particles merge.

Paolo Guasoni (Boston University)

Portfolios and risk premia for the long run

This paper develops a method to derive optimal portfolios and risk-premia explicitly in a general diffusion model, for an investor with power utility and in the limit of a long horizon. The market has several risky assets and is potentially incomplete. Investment opportunities are driven by, and partially correlated with, state variables which follow an autonomous diffusion. The framework nests models of stochastic interest rates, return predictability, stochastic volatility and correlation risk.

In models with several assets and a single state variable, long-run portfolios and risk-premia admit explicit formulas up the solution of an ordinary differential equation, which characterizes the principal eigenvalue of a elliptic operator. Multiple state variables lead to a partial differential equation, which is solvable for most models of interest.

For each value of the relative risk aversion parameter, the paper derives the long-run portfolio, its implied risk-premia and pricing measure, and their performance on a finite horizon.

Erika Hausenblas (University of Salzburg)

Maximal regularity for stochastic convolutions driven by Lévy noise

We are interested in the maximal regularity of the Ornstein-Uhlenbeck driven by purely discontinuous noise. In particular, let $(S,\mathcal{S})$ be a measurable space, E be a Banach space of martingale type p, $1<p\le 2$, and A be an infinitesimal generator of an analytic semigroup $(e^{-tA})_{0\le t<\infty}$ in E. We consider the following SPDE written in the Itô-form

$$\left\{ \begin{array}{rcl} du(t) &=& Au(t-)\,dt + \int_S \xi(t;x)\tilde{\eta}(dx;dt), \\ u(0) &=& 0, \end{array} \right. \tag{1}$$

where $\tilde{\eta}$ is a S valued compensated Poisson random measure defined over a filtered probability space $(\Omega;\mathcal{F};(\mathcal{F}_t)_{0\le t<\infty};\mathbb{P})$ with Lévy measure ν on S, specified later, and $\xi:\Omega\times S\to E$ is a progressively measurable process satisfying certain integrability conditions also specified later. The mild solution to (1) is called Ornstein-Uhlenbeck process and it is given by the following formula

$$u(t) := \int_0^t \int_S e^{-A(t-r)}\xi(r,x)\,\tilde{\eta}(dx;dr), \quad t>0.$$

Suppose $1\le q\le p$. Our main result is the following inequality

$$\boxed{\mathbb{E}\int_0^T |u(t)|^p_{D_A(\theta+\frac{1}{p},q)}\,dt \le C\mathbb{E}\int_0^T\int_S |\xi(t,z)|^p_{D_A(\theta,q)}\,dt,} \tag{2}$$

where $D_A(\theta,p)$, $\theta\in(0,1)$, denotes the real interpolation space of order θ between E and $D(A)$.

This presentation is based on a joint work with Brzeźniak (IST Lisbon).

Max-Olivier Hongler (Ecole Polytechnique Fédérale de Lausanne)

Connection between an exactly solvable stochastic optimal control problem and a nonlinear reaction-diffusion equation

An exactly soluble optimal stochastic control problem involving a diffusive two-state random evolution process will be presented. By using the technique of logarithmic transformations, our class of models is directly connected to a nonlinear reaction-diffusion type equation. The work generalizes the recently established connection between the non-linear Boltzmann-like equations introduced by Ruijgrok and Wu and the optimal control of a two-state random evolution process. In the sense of this generalization, the nonlinear reaction-diffusion equation is identified as the natural diffusive generalization of the Ruijgrok-Wu and Boltzmann model.

This presentation is based on a joint work with R. Filliger and L. Streit.

Peter Imkeller (Humboldt-Universität zu Berlin)

Meta-stability in some S(P)DEs related to simple climate models

Simple models of the earth's energy balance are able to interpret some qualitative aspects of the dynamics of paleo-climatic data. In the 1980s this led to the investigation of periodically forced dynamical systems of the reaction-diffusion type with small Gaussian noise, and a rough explanation of glacial cycles by Gaussian meta-stability. A spectral analysis of Greenland ice time series performed at the end of the 1990s representing average temperatures during the last ice age suggest an $\alpha-$stable noise component with an $\alpha \sim 1.75$. Based on this observation, papers in the physics literature attempted an interpretation featuring dynamical systems perturbed by small Lévy noise. We study exit and transitions between meta-stable states for solutions of stochastic differential equations and stochastic reaction-diffusion equations derived from this prototype. Due to the heavy-tail nature of the α-stable component of the noise, the results for Lévy noise differ strongly from the well known case of purely Gaussian perturbations. It has, however, been suggested that the exit and transition characteristics of dynamical systems perturbed by small Lévy noise approach Gaussian behavior as the heavy tails of their jump laws become exponentially light of order γ, i.e. if for $x \to \infty$ they are given by $\exp(-cx^\gamma)$, and as $\gamma \to 2$. We show that this is surprisingly false, by exhibiting a phase transition at $\gamma = 1$.

Interpreting paleo-climatic time series by simple dynamical systems with noise leads to statistical model selection problems. For instance, one needs an efficient testing method for the best fitting α-stable noise component. We develop a statistical testing method based on the p-variation of the solution trajectories of SDE with Lévy noise, for example by showing asymptotic normality or asymptotic β-stability of their approximations along finite interval partitions.

This presentation is based on a joint work with C. Hein, M. Högele, I. Pavlyukevich, and T. Wetzel.

Adam Jakubowski (Nicolaus Copernicus University)

On decomposability of stochastic processes of class D

Both the Doob-Meyer and the Graversen-Rao decomposition theorems can be proved following an approach based on predictable compensators of discretizations and weak-L^1 technique, which was developed by K.M. Rao. It is shown that any decomposition obtained by Rao's method gives predictability of compensators without additional assumptions (like submartingality in the original Doob-Meyer theorem or finite energy in the Graversen-Rao theorem).

A bounded stochastic process is constructed, which does not admit any decomposition of the Doob-Meyer type.

Agnessa Kovaleva (Mechanical Engineering Res. Institute, Russia)

Control of large deviations in Lagrangian systems with noise-independent residence time

We demonstrate the existence of a (non-optimal) dissipative control, generating a predetermined noise-independent residence time in a system subjected to potential forces and weak additive noise. We take a Hamiltonian system with weak noise as a basic uncontrolled model. The controlled system becomes dissipative with an attracting fixed point. The solution employs the large deviation principle. As in [1, 2], we construct a HJB equation for the logarithmic asymptotics of the residence time (in the small noise limit). We derive an explicit solution of the HJB equation in the form of a transformation of the Hamiltonian of the system. The closed-form solution allows choosing a control law so as to obtain the residence time independent of the noise intensity.

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Andreas Kyprianou (University of Bath)

De Finetti's control problem and spectrally negative Lévy processes

Suppose that X is a general spectrally negative Lévy process with probabilities $\{\mathbb{P}_x : x \in \mathbb{R}\}$. Consider the age-old (actuarial) control problem commonly attributed to de Finetti (1957) of finding the pair (v, L^*) such that

$$v(x) = \sup_{L \in \Pi} \mathbb{E}_x \left(\int_0^{\sigma^L} e^{-qt} dL_t \right) = \mathbb{E}_x \left(\int_0^{\sigma^{L^*}} e^{-qt} dL_t^* \right) \tag{1}$$

where $q > 0$, Π is a suitable class of dividend strategies, $L^* \in \Pi$ and for each $L \in \Pi$, $\sigma^L = \inf\{t > 0 : X_t - L_t < 0\}$ is the 'ruin time' of the controlled process.

Within the threshold strategies, there are two types of strategies which are known to lead to optimal solutions depending on the underlying structure of the Lévy process and the class Π of permissible dividend strategies. The first type of strategy corresponds to *reflecting* X at a barrier of level $b > 0$. In that case $L_t^* = b \vee \overline{X}_t - b$ where $\overline{X}_t = \sup_{s \leq t} X_s$. See for example the discussion in Bühlmann (1970) where one finds reference to the work of de Finetti who proposed this problem and solution in a discrete time setting. The second type of strategy, introduced in a variant of the original problem by Jeanblanc and Shiryaev (1995) and Asmussen and Taksar (1995), corresponds to *refracting* X at a barrier of level $b > 0$. In short this means subtracting a linear drift off from X with an appropriate rate $\delta > 0$ whenever the aggregate process increases above the level b. Hence the aggregate process is descri bed by the stochastic differential equation

$$U_t = X_t - \delta \int_0^t \mathbf{1}_{\{U_s > b\}} ds. \tag{2}$$

Within the class of Lévy processes, the aforementioned strategies have been explored in the case that X is either a linear Brownian motion or a compound Poisson process with drift and exponentially distributed negative jumps.

When dealing with (1) in the general setting of a spectrally negative Lévy process, even when the jump structure is that of a compound Poisson process with a general (negatively supported) jump distribution, there are many complications which enter the analysis. Indeed, it is known that a threshold strategy of the type described above is not necessarily optimal. None the less, thanks to recent developments in the general theory of Lévy processes, re-examining this problem has become possible and the last two years has seen a sequence of (as of yet mostly unpublished) results pertaining to existence and characterization of the solution to (1) in a considerably more general setting. Key to the analysis is the theory of so-called *scale functions* for spectrally negative Lévy processes, which itself has attracted some attention and development in the last few years. Another problem arising is the existence and uniqueness of solutions to (2). Despite its remarkably simple form, it fits in to the class of degenerate SDEs driven by Lévy processes when there is no Gaussian component present for which there seems to be limited results available.

The purpose of this talk is to give a review of the very recent family of research papers written in this direction (authored by Avram, Pistorius, Palmowski, Loeffen, Hubalek, Rivero, Song and K.). Specifically we shall be concerned with the important role of scale functions for spectrally negative Lévy processes in:

(a) establishing existence and uniqueness of strong solutions to (2),

(b) establishing analytical expressions for the value of the two types of threshold strategies given above,

(c) establishing optimality criteria.

Since many of the calculations will involve scale functions and the latter are only determined up to knowing their Laplace transform, the presented material suffers the criticism of 'expressing one unknown in terms of another unknown'. Also in this talk we shall aim to address this criticism by exposing a method for generating numerous explicit examples of scale functions, where previously scarcely a handlful examples have been available.

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Paul Lescot (Université de Picardie)

Isovectors for the Black-Scholes equations

We compute the isovectors for the Black-Scholes equations by a method broadly similar to the one used for the heat equation (resp. the heat equation with potential term) in joint papers with J.-C. Zambrini (see the Proceedings of the previous two Ascona conferences : Progress in Probability vols 58 and 59). It turns out that this computation leads naturally to Black and Scholes' original solution method for their equation ; in particular, the quantities $r - \frac{\sigma^2}{2}$ and $r + \frac{\sigma^2}{2}$ appear naturally. In addition, a relation to the so-called call-put parity relation is established.

Wei Liu (Universität Bielefeld)

Large deviations for evolution equations with small multiplicative noise

The Freidlin-Wentzell large deviation principle is established for the distributions of stochastic evolution equations with general monotone drift and small multiplicative noise. Roughly speaking, besides the standard assumptions for existence and uniqueness of strong solutions, one only needs to assume some additional assumptions on diffusion coefficient in order to establish large deviation principle. As applications we can apply the main result to different type examples of SPDEs (e.g. stochastic reaction-diffusion equation, stochastic porous media and fast diffusion equations, stochastic p-Laplacian equation) in Hilbert space. The weak convergence approach is employed to verify the Laplace principle, which is equivalent to large deviation principle in our framework.

József Lorinczi (University of Loughborough)

Exponential integrability of rough functional and weak limits

Motivated by applications in mathematical physics I will address the problem of how to construct Gibbs measures on Brownian paths subjected to interactions dependent on double stochastic integrals. Even the definition of such measures for bounded intervals of the real line is problematic as a pathwise control with respect to boundary conditions is necessary. I will explain how to cope with this by introducing the framework of Brownian currents, and will address the problem of existence, uniqueness and properties of limiting Gibbs measures by a combination of rough paths analysis and cluster expansion methods.

Anatoliy Malyarenko (Mälardalen University)

A family of series representations of the multiparameter fractional Brownian motion

We derive a family of series representations of the multiparameter fractional Brownian motion in the centred ball of radius R in the N-dimensional space $\mathbb{R}^N$. Some known examples of series representations are shown to be the members of the family under consideration.

For complete version, please see `http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.4076v1.pdf`

Bohdan Maslowski (Academy of Sciences of the Czech Republic)

Ergodic control in infinite dimensions

We study the ergodic control problem for a class of stochastic evolution equations of semilinear type. The basic example we have in mind is the following reaction-diffusion equation

$$\begin{cases} \frac{\partial X}{\partial t}(t,\zeta) = \frac{\partial^2 X}{\partial \zeta^2}(t,\zeta) + g(X(t,\zeta)) - u_t + \frac{\partial^2 W}{\partial t \partial \zeta}(t,\zeta), \\ X(t,0) = X(t,1) = 0, \\ X(0,\zeta) = x(\zeta),\ 0 \le \zeta \le 1,\ t \ge 0, \end{cases} \tag{1}$$

with the Dirichlet boundary conditions. The process W is a space-time white noise and $g : R \to R$ is a Lipschitz mapping.

We show existence and uniqueness of solutions to the corresponding Hamilton-Jacobi equation (2) and thereby obtain the unique optimal control given in the feedback form. We dealt with a similar problem in the paper [5], where however partly different technical tools have been used, which required "sufficient dissipativity" of the system (or dually, a technical restriction on the size of controls). Here we use a different approach based on a uniform V-ergodicity result that was obtained recently (cf. Goldys and Maslowski, [6]). We also solve the respective adaptive control problem for the system with an unknown parameter in the drift.

The equation (1) is reformulated and generalized to a stochastic evolution equation in a separable Hilbert space $\mathscr{X}$. The Dynamic Programming Principle combined with the recent results on transition semigroups of infinite dimensional diffusions is used to show that there exists a unique (up to an additive constant) smooth solution (v, λ) to the associated Hamilton-Jacobi equation

$$\frac{1}{2}\operatorname{tr}\left(D^2 v(x)\right) + \langle Ax + F(x), Dv(x)\rangle + f(x) - H(Dv(x)) - \lambda = 0, \tag{2}$$

where H denotes the Hamiltonian of the problem and D stands for the Fréchet derivative. Then λ gives the optimal cost of the ergodic control problem and $DH(Dv(\cdot))$ is the unique optimal feedback control. For the adaptive control problem, the mapping F is allowed to depend on a parameter $\alpha \in \mathscr{A} \subset \mathbb{R}^n$.

In the finite dimensional case methods of solving (2) are relatively well developed. Usually equation (2) is approximated by a sequence of the stationary Hamilton-Jacobi equations (for discounted cost problems) on bounded domains. Then by the use of appropriate Sobolev-type estimates and compact imbeddings our solution is found as a suitable limit of renormalized solutions to this sequence of equations (see e.g. the monographs by Bensoussan [1] and Borkar [3]). Unfortunately, results of this type are not available in infinite dimensions. For the infinite-dimensional results, beside the aforementioned paper [5], we would like to mention the forthcoming paper by Fuhrman, Hu and Tessitore [4] where the ergodic control problem for similar systems has been solved by means of ergodic BDSEs under different set of assumptions.

We consider a controlled process (X_t) defined by an equation

$$\begin{cases} dX_t = \left(AX_t + F\left(\alpha, X_t\right) - u_t\right) dt + dW_t, \\ X_0 = x \in X,\ t \geq 0, \end{cases} \tag{3}$$

in a separable Hilbert space $(\mathscr{X}, \langle\cdot,\cdot\rangle, |\cdot|)$, where $A : \operatorname{dom}(A) \to \mathscr{X}$ generates a strongly continuous semigroup $S(\cdot)$ on $\mathscr{X}$ and (W_t) is a cylindrical Wiener process on $\mathscr{X}$ defined on a probability space $(\Omega, \mathscr{F}, (\mathscr{F}_t), P)$. The control u is said to be admissible if u is an $\mathscr{X}$-valued, adapted process and $u(t) \in B_R$ *a.s.* for each $t \geq 0$, where $B_R = \{x \in \mathscr{X};\ |x| \leq R\}$ and $R > 0$ is arbitrary and fixed. The set of all admissible controls will be denoted by $\mathscr{U}$. The cost functional to be minimized is

$$V(x, u) = \liminf_{T\to\infty} \mathbb{E}_{x,u}\left(\frac{1}{T}\int_0^T \left(f\left(X_t\right) + h\left(u(t)\right)\right) dt\right),$$

where $f : \mathscr{X} \to \mathbb{R}$ and $h : B_R \to \mathbb{R}_+$.

Hypothesis 1. *There exist $\omega > 0$ and $\gamma > 0$ such that*

$$\|S(t)\| \leq e^{-\omega t}, \quad t \geq 0, \tag{4}$$

and for a certain $T > 0$

$$\int_0^T t^{-\gamma} \|S(t)\|_{HS}^2 \, dt < \infty, \tag{5}$$

where $\|\cdot\|_{HS}$ denotes the Hilbert-Schmidt norm of an operator.

Hypothesis 2. *For each $\alpha \in \mathscr{A}$ the function $F(\alpha, \cdot) : \mathscr{X} \to \mathscr{X}$ is Lipschitz continuous and there exist positive constants C, k_1, k_2, k_3 and θ such that*

$$\langle Ax + F(\alpha, x + y), x\rangle \leq -k_1|x|^2 + k_2|y|^\theta + k_3, \quad x \in \operatorname{dom}(A), y \in \mathscr{X}, \tag{6}$$

and

$$|F(\alpha, x)| \leq C(1 + |x|), \quad x \in \mathscr{X}. \tag{7}$$

Hypothesis 3. *For each $x \in \mathscr{X}$ the mapping $F(\cdot, x) : \mathscr{A} \to \mathscr{X}$ is continuous.*

The following conditons are imposed on the cost functional V.

Hypothesis 4. *The function $h : \mathscr{X} \to \mathbb{R}_+$ is convex, lower semicontinuous and bounded on bounded sets. The Hamiltonian $H : \mathscr{X} \to \mathbb{R}$ given by the formula*

$$H(x) = \sup_{|y| \leq R} (\langle y, x \rangle - h(y))$$

is continuously Fréchet differentiable.

Hypothesis 5. *$f : \mathscr{X} \to \mathbb{R}$ and there exists $m_0 \geq 0$ such that the mapping*

$$x \to \frac{|f(x)|}{1 + |x|^{m_0}}$$

is bounded and uniformly continuous on $\mathscr{X}$.

As usual, we denote by $BUC_m^k(\mathscr{X})$ the space of functions on $\mathscr{X}$ that are $k-$times Frechet differentiable and all respective derivatives, if divided by the polynomial weight $\rho_m(x) = 1 + \|x\|_m$, are bounded and uniformly continuous. By the solution to the ergodic HJB equation (2) we understand a pair $(v, \lambda) \in BUC_m^1(\mathscr{X}) \times \mathbb{R}$ for a suitable m, satisfying

$$L_m v + < F, Dv > - H(Dv) + f - \lambda = 0,$$

where L_m denotes the generator of the OU semigroup in the space $BUC_m^1(\mathscr{X})$. Our main results on ergodic control are summarized here:

Theorem 6. *For a fixed value of the parameter α, there exists a unique solution (v, λ) to equation (2) in the space $BUC^1_{m_0+1}(\mathscr{X}) \times R$ satisfying $v(0) = 0$. Furthermore, let (w, λ) be an arbitrary solution to the HJB equation (2). Then the following holds: (a) For any admissible control $u \in \mathscr{U}$ and $x \in \mathscr{X}$ we have*

$$V(x, u) \geq \lambda. \tag{8}$$

(b) Let $\tilde{u} \in \mathscr{U}$ be an admissible control such that

$$\lim_{t \to \infty} (\tilde{u}(t) - \bar{u}(t)) = 0 \quad \text{in} \quad \mathbb{P}_{x, \tilde{u}}, \tag{9}$$

where $\bar{u}(t) = DH\,(DV\,(X_t))$. Then

$$V\,(x, \tilde{u}) = \lambda. \tag{10}$$

Corollary 7. *Let the assumptions of Theorem 6 be satisfied and let $\hat{u}(t) = DH\,(Dv\,(X_t))$, i.e. (X_t) is a solution of the closed loop equation ($u = \hat{u}$). Then $\hat{u}(t) = \tilde{u}(t)$ trivially satisfies (9) (since $\tilde{u} = \bar{u}$), hence $V\,(x, \hat{u}) = \lambda$. Thus, by (8) $\hat{u}$ is an optimal control and ρ is the optimal cost of the ergodic control problem.*

For the adaptive control problem, given a strongly consistent family of estimators (α_t), the control defined by the closed loop equation with $u_t = DH(Dv^{(\alpha_t)}(X_t))$, where $(v^\alpha, \lambda(\alpha))$ is the solution to the ergodic HJB equation with the parameter α, may be shown to be the optimal one. To prove this, a continuous dependence of solutions to HJB equations on the parameter must be shown. Then Theorem 6 (b) may be used.

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This presentation is based on a joint work with B. Goldys (School of Mathematics, University of New South Wales).

Jonathan C. Mattingly (Duke University)

The spread of randomness in infinite dimensions and ergodicity for SPDEs

Eddy Mayer-Wolf (Technion - Israel Institute of Technology)

Banach-valued Wiener functionals and their divergence

The domain of definition of the divergence operator on an abstract Wiener space (W, H, μ) is extended to include appropriate W- (and $W \otimes W$-) valued "integrands". Under appropriate conditions, these vector fields may generate quasiinvariant flows. However, in some sense the only new (not H-valued) "integrands" have zero divergence, and the flows they generate leave μ invariant.

This presentation is based on a joint work with Moshe Zakai.

Annie Millet (Université de Paris I)

On large deviation for stochastic 2d hydrodynamical systems

Let u^ϵ be the solution to a non-linear stochastic evolution equation, such as the Navier Stokes equation coupled with other equations describing the dynamics of a heat parameter and a magnetic field. This global equation describes convection systems appearing or examples in phenomena of weather and climate dynamics, or the interaction between the velocity and the magnetic field in a plasma. It extends both the stochastic Boussinesq equation and the stochastic MHD one, and the perturbation is driven by a Hilbert-valued Wiener process.

Let $V \subset H$ denote Hilbert spaces, such as $H^1 \subset L^2$ for the Bénard problem. Under weak hypotheses on the diffusion coefficient, we at first prove existence, uniqueness and establish apriori bounds in a space $\mathscr{X} = C([0,T], H) \cap$

$L^2([0,T],V)$ for controlled SPDEs, that is when in the previous model one shifts the Wiener process by a random element of its RKHS.

Under more restrictive assumptions on the diffusion coefficient, we prove a large deviation principle in $\mathscr{X}$ for the family u^ϵ. The proof is based on the weak convergence for solutions of the above stochastic controlled equations. These results have been proved in joint works with J. Duan and I. Chueshov.

Carl Mueller (University of Rochester)

Negative moments for a linear SPDE

When using Malliavin Calculus to study the smoothness of solutions to stochastic equations, we often differentiate the original equation to obtain a linear equation for the derivative. Next, among other things, we study the moments of the derivative, of both positive and negative orders. Following this motivation, we study the negative moments of solutions to a linear SPDE, and show that the moments are finite in some cases.

This presentation is based on a joint work with David Nualart.

Ivan Nourdin (Université de Paris VI)

Stein's method and weak convergence on Wiener chaos

We will show that one can combine Malliavin calculus with Stein's method, in order to derive explicit bounds in the Gaussian and Gamma approximations of arbitrary regular functionals of a given Gaussian field (here, the notion of regularity is in the sense of Malliavin derivability). When applied to random variables belonging to a fixed Wiener chaos, our approach generalizes, refines and unifies the central and non-central limit theorems for multiple Wiener-Itô integrals recently proved (in several papers, from 2005 to 2007) by Nualart, Ortiz-Latorre, Peccati, Tudor and myself. We shall discuss some connections with the classical method of moments and cumulants. As an application, we deduce explicit Berry-Esséen bounds in the Breuer-Major central limit theorem for subordinated functionals of a fractional Brownian motion.

This presentation is based on a joint work with Giovanni Peccati (Université de Paris VI).

Jan Obloj (Imperial College London)

Model-free pricing and hedging of double barrier options via new solutions to the Skorokhod embedding problem

We investigate bounds on the joint law of maximum and minimum of a uniformly integrable martingale with fixed terminal distribution. We obtain explicit bounds and constructions which achieve them - this corresponds to designing new optimal solutions to the Skorokhod embedding problem.

We apply these ideas to model-free pricing of digital options, which pay out depending on whether the underlying asset has crossed upper and lower levels. We make only weak assumptions about the underlying process (typically continuity), but assume that the initial prices of call options with the same maturity and all strikes are known. Treating this market data as input, our probabilistic results induce upper and lower bounds on the arbitrage-free prices of the relevant options, and show that these bounds are tight. Additionally, martingale inequalities are derived, which provide the trading strategies with which we are able to realize any potential arbitrages.

This presentation is based on a joint work with Alexander Cox (University of Bath).

Edwin Perkins (University of British Columbia, Vancouver)

Pathwise uniqueness for stochastic heat equations with Hölder continuous coefficients: the white noise case

We prove pathwise uniqueness for solutions of parabolic stochastic pde's with multiplicative white noise if the coefficient is Hölder continuous of index $\gamma > 3/4$. The method of proof is an infinite-dimensional version of the Yamada-Watanabe argument for ordinary stochastic differential equations.

This presentation is based on a joint work with Leonid Mytnik.

Hûzen Pham (Université de Paris VI and VII)

Pricing and hedging with execution delay

We consider impulse control problems in finite horizon for diffusions with decision lag and execution delay. The new feature is that our general framework deals with the important case when several consecutive orders may be decided before the effective execution of the first one. This is motivated by financial applications in the trading of illiquid assets such as shares of hedge funds, where selling orders are executed with one to three months of delay, inducing an important risk for the investor. We show that the value functions for such control problems satisfy a suitable version of dynamic programming principle in finite dimension, which takes into account the past dependence of state process through the pending orders. The corresponding Bellman partial differential equations (PDE) system is derived, and exhibit some peculiarities on the coupled equations, domains and boundary conditions. We prove a unique characterization of the value functions to this nonstandard PDE system by means of viscosity solutions. We then provide an algorithm to find the value functions and the optimal control. This implementable algorithm involves backward and forward iterations on the domains and the value functions, which appear in turn as original arguments in the proofs for the boundary conditions and uniqueness results. Finally, we give several numerical experiments illustrating the impact of execution delay on trading strategies and on option pricing.

Eckhard Platen (University of Technology, Sydney)

Conditions for martingales, with applications in finance

In order to apply risk-neutral pricing, one must first check that the chosen density process for an equivalent change of probability measure is in fact a martingale. If not, risk-neutral pricing may not be possible, and the market model may contain "bond bubbles". Even if the density process is a martingale, however, it is still possible that a discounted asset price process could be a strict local martingale under the risk-neutral probability measure. In this case, the market model may contain "asset bubbles". Applying the benchmark approach we identify examples of these phenomena, and examine their consequences. On the mathematical side this paper considers the problem when a non-negative local martingale is a martingale or a universally integrable martingale. In the case of time-homogeneous diffusions in natural scale, necessary and sufficient conditions are derived for answering both questions. These results are widely applicable to problems in stochastic finance and other areas.

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This presentation is based on a joint work with Hardy Hulley.

Arturo Romer (Università della Svizzera Italiana)

Energie, effet serre et les implications à niveau planétaire sur la base des modèles du GIEC *

Le conférencier présentera la consommation énergétique actuelle et future au niveau planétaire. Il en illustrera les implications respectives de nature économique, écologique et sociale. Une importance particulière sera consacrée à l'effet de serre et aux modèles physico-mathématiques respectifs. Le conférencier discutera les stratégies de gestion environnementale et énergétique qui pourront contenir les dégâts à long-moyen terme. Grande importance sera jouée par le concept de développement durable.

Marco Romito (Università di Firenze)

The martingale problem for the Navier-Stokes equations

A short review on the martingale problem for the Navier-Stokes equations: existence of a Markov process which is a solution to the equations, long time behavior and a connection with the critical regularity in the hierarchy of Sobolev spaces.

Bernard Roynette (Nancy-Université)

A global view of Brownian penalisations

With the help of Feynman-Kac type penalisation results related to Wiener measures, we construct a positive and σ-finite measure $\mathscr{W}$ on the canonical space $\big(\Omega = \mathscr{C}(\mathbb{R}_+, \mathbb{R}), (X_t)_{t\geq 0}, (\mathscr{F}_t)_{t\geq 0}\big)$. Then we explicit relationships between $\mathscr{W}$ and the family of probability measures (on the canonical space) which are obtained by penalisations of the Wiener measure. Finally, we present the main properties of $\mathscr{W}$.

*GIEC = Groupe d'experts intergouvernemental sur l'évolution du climat.

Barbara Rüdiger(Universität Koblenz Landau)

Mild solutions of infinite dimensional stochastic differential equations with Lévy noise

In an article joint with S. Albeverio, V. Mandrekar [1] we analyzed some Hilbert valued SPDE with Lévy noise, in very much generality. It turned out that for some particular Hilbert spaces and involving further requirements on the drift term, these Hilbert valued SPDEs describe the time evolution of forward interest rates in the Heath -Jarrow -Morton model studied in [2], [3], [4]. In [1] we analyze existence and uniqueness of the solution under Lipschitz conditions of noise and drift coefficient (where also dependence of the coefficients on the past paths are allowed), continuous dependence of the solution on drift and noise coefficient, and differential dependence of the solution on the initial data.

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Marta Sanz-Solé (Universitat de Barcelona)

Some properties of the density for a 3-d stochastic wave equation

We consider a stochastic wave equation in space dimension three driven by a noise white in time and with an absolutely continuous correlation measure given by the product of a smooth function and a Riesz kernel. Let $p_{t,x}(y)$ be the density of the law of the solution $u(t,x)$ of such an equation at points $(t,x) \in]0,T] \times \mathbb{R}^3$. We prove that the mapping $(t,x) \mapsto p_{t,x}(y)$ owns the same regularity as the sample paths of the process $u(t,x), (t,x) \in]0,T] \times \mathbb{R}^3$. The proof relies on the integration by parts formula of Watanabe and estimates derived form it.

Walter Schachermayer (Vienna University of Technology)

Hiding the drift

In this article we consider a Brownian motion with drift, denoted by $S = (S_t)_{t\geq 0}$, of the form

$$dS_t = \mu_t dt + dB_t \quad \text{for } t \geq 0,$$

with a specific non-trivial drift predictable with respect to $\mathbb{F}^B$, the natural filtration of the Brownian motion $B = (B_t)_{t\geq 0}$. We construct a process $H = (H_t)_{t\geq 0}$

also predictable with respect to $\mathbb{F}^B$ such that $((H \cdot S)_t)_{t \geq 0}$ is a Brownian motion in its own filtration. Furthermore, for any $\delta > 0$, we refine this construction such that the drift $(\mu_t)_{t \geq 0}$ only takes values in $]\mu - \delta, \mu + \delta[$ for fixed $\mu > 0$.

This presentation is based on a joint work with Miklós Rásony and Richard Warnung.

Juergen Schmiegel (Aarhus University)

Stochastic modeling of the turbulent velocity field

We discuss a stochastic modelling framework for the timewise dynamics of the main component v_t of the turbulent velocity field at a fixed position x and at time t. The model is given by an ambit process [1] of the form [2]

$$v_t = \int_{-\infty}^{t} g(t-s)\sqrt{J_s(x)}\mathrm{d}B_s + \beta \int_{-\infty}^{t} g(t-s) J_s(x) \mathrm{d}s \tag{1}$$

where g is a deterministic kernel, β is a constant and B denotes Brownian motion. The stochastic process J is called the intermittency process. We model the process J by a stochastic intermittency field [3] that represents a continuous cascade process [4]

$$J_t(x) = \exp\left\{ \int_{t-T}^{t} \int_{x-r(s-t+T)}^{x+r(s-t+T)} L(\mathrm{d}s \times \mathrm{d}\sigma) \right\} \tag{2}$$

where r is a deterministic window function and L is a Lévy basis (an infinitely divisible and independently scattered random measure).
Within our modelling framework we are able to reproduce the observed heavy tailed distributions for turbulent velocity increments and the scaling properties of structure functions. Moreover, the model also captures the scaling behaviour of energy dissipation correlators and the scaling behaviour of the coarse grained energy dissipation process. Finally we show that the proposed model also reveals the conditional independence of the distribution of the Kolmogorov variable

$$V_t = \frac{v_t - v_0}{(t\varepsilon_t)^{1/3}}, \tag{3}$$

conditioned on the integrated energy dissipation $t\varepsilon_t$ over a horizon of length t. We also discuss possible generalizations of the modelling framework (1) to a model for the turbulent velocity field in space and time.

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This presentation is based on a joint work with O.E. Barndorff-Nielsen.

Ronnie Sircar (Princeton University)

Analysis and application of multiscale stochastic volatility models

We discuss empirical motivations for long and short time scales in models of stochastic volatility based on diffusion processes. These have applications for pricing equity derivatives, interest rate products and credit derivatives, and calibrating implied volatilities, yield curves and credit spreads. They are analyzed by combined regular and singular asymptotic approximations. We illustrate performance on market options data.

Wilhelm Stannat (Technische Universität Darmstadt)

The logarithmic Sobolev inequality for the Wasserstein diffusion

We prove that the Dirichlet form associated with the Wasserstein diffusion on the set of all probability measures on the unit interval, recently introduced by M.K. von Renesse and K.T. Sturm, satisfies a logarithmic Sobolev inequality. This implies hypercontractivity of the associated transition semigroup. We also study functional inequalities for related diffusion processes.

Andrew Stuart (University of Warwick)

Mathematical foundations of data assimilation problems arising in fluid mechanics

The explosion of data gathering over the last few decades has been, and will continue to be, phenomenal [14]. There has also been a massive change in the scale of computational power which is now routinely available. These technology-driven changes are leading to both the need for inference on massive and highly heterogeneous data sets, and for the possibility of modelling ever more complex structures and systems. Making sense of data, in the context of the modelling of complex systems, is a very challenging task. The field of statistics provides a rational basis for the analysis of data. On the other hand, in many application areas, there is an enormous amount of information in the form of sophisticated mathematical models, often developed over decades or centuries. As a consequence of these advances in technology, applied mathematics and statistics are required to work in concert in order to significantly progress understanding. Blending these two view points – statistics, which is data driven, and mathematical modelling which provides systematic predictive tools – leads to the field of *data assimilation*. The aim of this talk is to describe a mathematical framework for the analysis of a range of problems of this type which arise in fluid mechanics. We are particularly motivated by problems arising in weather forecasting [4, 7, 10, 15, 19] and oceanography [2, 3, 13, 16, 20] in which

Eulerian or Lagrangian measurements of a velocity field must be incorporated into a mathematical model in order to optimally blend information.

Despite the increasing importance of data assimilation in many applications of fluid mechanics, there has been no attempt to develop the rigorous mathematical underpinnings of the subject. The problem is inherently one of Bayesian statistics [17] in a function space. Developing the underpinnings of the subject is important for a number of reasons. For example, in order to be able to evaluate various approximations made in practice, such as variational methods [10], which amount to approximating the posterior measure by a Dirac, and more refined Gaussian approximations [19], it is necessary to have a well-defined posterior measure. Furthermore, it is advantageous in the construction of Markov chain-Monte Carlo (MCMC) methods to be able to define algorithms on function space, as it is approximation of these algorithms which leads to well behaved finite (but high) dimensional sampling algorithms [1, 5].

We establish a mathematical framework for a range of data assimilation problems arising in fluid mechanics. We study problems in which either Eulerian or Lagrangian observations are made, and the objective is to make inference about the underlying velocity field. We study problems without model error, in which case the inference is on the initial condition, and problems with mean zero Gaussian model error, in which case the inference is on the initial condition and on the driving noise process or, equivalently, on the entire time-dependent velocity field. Having given firm mathematical foundations for the Bayesian viewpoint, we then study MCMC methods to sample the posterior measure. The common mathematical structure which we will exploit is that the posterior measure has density with respect to a Gaussian reference measure on a Hilbert space. The MCMC methods we introduce are defined on function space, and consequently they behave well under refinement of any finite dimensional approximation.

In order to undertake a clean mathematical analysis we consider the two-dimensional Navier-Stokes equations on a torus. The case of Eulerian observations – direct observations of the velocity field itself – is then close to the situation in weather forecasting. The case of Lagrangian observations – observations of passive tracers adverted by the flow – is then close to the situation arising in oceanography. The methodology which we describe herein may be applied to many other problems in which it is of interest to sample, given observations, an infinite-dimensional object such as, in this case, the initial condition of a dynamical system in infinite dimensions. A similar approach might be adopted, for example, to determine a field arising as a constitutive model in a PDE.

We start the talk by describing various mathematical preliminaries that will be useful throughout. We then introduce various data assimilation problems. We show these these give rise to well-defined sampling problems on function space by developing a theory in which conditions are given on the prior reference measure sufficient to ensure that the posterior measure makes sense. Furthermore we develop properties of the posterior measure which will be useful for the definition and analysis of MCMC methods. We conclude by studying MCMC for these function space sampling problems and show how, with appropriate choice of proposal distributions, effectively sampling be achieved.

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This presentation is based on a joint work with Simon Cotter, Masoumeh Dashti and James Robinson.

Karl-Theodor Sturm (Universität Bonn)

Optimal transportation, gradient flows and Wasserstein diffusion

We present a brief introduction to recent progress in optimal transportation on manifolds and metric spaces. We recall the characterization of the heat equation on Riemannian manifolds M as the gradient flow for the relative entropy on the L^2-Wasserstein space of probability measures $\mathscr{P}(M)$, regarded as an infinite dimensional Riemannian manifold. Of particular interest are recent extensions to the (nonlinear!) heat flow on Finsler spaces.

Convexity properties of the relative entropy $Ent(.|m)$ also play an important role in a powerful concept of generalized Ricci curvature bounds for metric measure spaces (M, d, m).

Moreover, we indicate how to construct a canonical reversible process $(\mu_t)_{t\geq 0}$ on the Wasserstein space $\mathscr{P}(\mathbb{R})$. This process has an invariant measure $\mathbb{P}^\beta$ which may be characterized as the 'uniform distribution' on $\mathscr{P}(\mathbb{R})$ with weight function $\frac{1}{Z}\exp(-\beta \cdot Ent(.|m))$ where m denotes a given finite measure on $\mathbb{R}$. One of the key results is the quasi-invariance of this measure $\mathbb{P}^\beta$ under push forwards $\mu \mapsto h_*\mu$ by means of smooth diffeomorphisms h of $\mathbb{R}$.

Gianmario Tessitore (Università di Milano Bicocca)

Ergodic BSDEs and optimal ergodic control in Banach spaces with unbounded generator

We introduce a new kind of Backward Stochastic Differential Equation, called ergodic BSDEs, which arise naturally in the study of optimal ergodic control. We study the existence, uniqueness and regularity of solutions to ergodic BSDEs. Then we apply these results to the optimal ergodic control of a Banach valued stochastic state equation. We also establish the link between the ergodic BSDEs and the associated Hamilton-Jacobi-Bellman equation.

Using new techniques and results concerning BSDEs in infinite horizon with unbounded generator the results are then extended to the case of non-bounded cost functionals.

Applications are given to ergodic control of stochastic partial differential equations.

Samy Tindel (Nancy-Université)

On fractional differential systems

In this talk, we will describe some recent results concerning stochastic differential systems driven by a multidimensional fractional Brownian motion with Hurst parameter $1/3 < H < 1/2$. Indeed, most of the results of the rough paths theory concern fractional diffusion processes. However, using a slight modification of this theory, we have been able to extend the method to other kind of situations. We shall try to give an overview of three of them: delay and Volterra equations, as well as PDEs.

Gerald Trutnau (Universität Bielefeld)

Pathwise uniqueness of the squared Bessel process and CIR process, with skew reflection a deterministic time-dependent curve

Let $\sigma, \delta > 0, b \geq 0$. Let $\lambda^2 : \mathbb{R}^+ \to \mathbb{R}^+$, be continuous, not necessarily absolutely continuous, and locally of bounded variation. We develop a general analytic criterion for pathwise uniqueness of

$$R_t = R_0 + \int_0^t \sigma\sqrt{|R_s|}dW_s + \int_0^t \frac{\sigma^2}{4}(\delta - bR_s)ds + (2p-1)\ell_t^0(R-\lambda^2),$$

where $p \in (0,1)$, and where $\ell_t^0(R-\lambda^2)$ is the symmetric semimartingale local time of $R-\lambda^2$. The criterion is related to the existence of certain sub-superharmonic functions for the associated parabolic generator, which is a more complex object than its time homogeneous counterpart. As an application, we show that pathwise uniqueness holds, if

$$\overline{p}d\lambda^2(s) \leq \overline{p}\frac{\sigma^2}{4}\left\{\delta - \left(\frac{1-\overline{p}}{2}\right)b\lambda^2(s)\right\}ds.$$

where $\overline{p} := sgn(2p-1)$, and sgn is the point-symmetric sign function. The inequalities are to be understood in the sense of signed measures on $\mathbb{R}^+$. For

instance, if $2p-1>0$, $\sigma=2$, this means that the increasing part of λ^2 is Lipschitz continuous with Bessel dimension δ as Lipschitz constant, and that the decreasing part is arbitrary. Or, if $2p-1<0$, and e.g. $\lambda^2 \equiv const = c$, this means that $c \geq \frac{\delta}{b}$.
Weak existence of R is established in various cases. In particular, there is no solution if $|p|>1$.

Frederic Utzet (Universitat Autònoma de Barcelona)

Multiple Stratonovich integral and Hu–Meyer formula for Lévy processes

Combining the ideas of Hu and Meyer [1] and Rota and Wallstrom [3], we will present an Itô multiple integral and a Stratonovich multiple integral with respect to a Lévy process with finite moments up to a convenient order. The Stratonovich multiple integral is an integral with respect to a product measure whereas the Itô multiple integral is the integral with respect to a measure that gives zero mass to the diagonal sets, like $\{(s_1,\ldots,s_n)\in\mathbb{R}^n_+,\ s_1=s_2\}$. The main tool in our construction is the powerful combinatorial machinery introduced by Rota and Wallstrom [3] for random measures, where the diagonal sets of $\mathbb{R}^n_+$ are identified with the partitions of the set $\{1,\ldots,n\}$. The key point is to understand how the product of stochastic measures works on the diagonal sets, and that leads to the diagonal measures defined by Rota and Wallstrom [3]. For a Lévy process those measures are related to the powers of the jumps of the process, and hence with a family of martingales introduced by Nualart and Schoutens [2], called Teugels martingales, which enjoy very nice properties. With all these ingredients we prove a general Hu–Meyer formula. As particular cases, we deduce the classical Hu–Meyer formulas for the Brownian motion and for the Poisson process.

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This presentation is based on a joint work with Mercè Farré and Maria Jolis.

Esko Valkeila (Helsinki University of Technology)

An extension of the Lévy characterization to fractional Brownian motion

The well known Lévy characterization of classical Brownian motion says that a continuous centered square integrable process X is Brownian motion if and only if it is a martingale and the process $X^2(t) - t$ is a martingale. In the talk we discuss two related extansions of this theorem to fractional Brownian motion.

Pierre Vallois (Nancy-Université)

Penalizations of Brownian motion with its maximum and minimum processes as weak forms of Skorokhod embedding

Let $\big(\Omega = \mathscr{C}(\mathbb{R}_+, \mathbb{R}),\ (X_t)_{t\geq 0},\ (\mathscr{F}_t)_{t\geq 0}\big)$ be the canonical space, where $(X_t)_{t\geq 0}$ denotes the coordinate maps : $X_t(\omega) = \omega(t)$, for any $t \geq 0$. Let $(P_x)_{x\in\mathbb{R}}$ be the family of Wiener probability measures on Ω : under P_x, $(X_t)_{t\geq 0}$ is a standard one-dimensional Brownian motion started at x.
Next, we consider a stochastic process $(F_t)_{t\geq 0}$ which takes its values in $[0, \infty[$ and satisfies : $0 < E_0(F_t) < \infty$, for all $t \geq 0$. Assume that :

$$\frac{E_0[F_t|\mathscr{F}_s]}{E_0(F_t)} \underset{t\to\infty}{\overset{\text{a.s.}}{\longrightarrow}} M_s^F, \quad \text{and} \quad E_0(M_s^F) = 1 \quad (\forall s \geq 0). \tag{1}$$

Then, $(M_s^F\ ;\ s \geq 0)$ is a non-negative P_0-martingale and for any $s \geq 0$ and $\Lambda_s \in \mathscr{F}_s$:

$$\lim_{t\to\infty} \frac{E_0[1_{\Lambda_s} F_t]}{E_0[F_t]} = Q_0^F(\Lambda_s)$$

(i.e. a penalization procedure, associated with the weight process (F_t) holds).
We develop a Brownian penalization procedure related to weight processes (F_t) of the type : $F_t := f(I_t, S_t)$ where f is a bounded function with compact support and S_t (resp. I_t) is the one-sided maximum (resp. minimum) of the Brownian motion up to time t. Two main cases are treated : either F_t is the indicator function of $\{I_t \geq \alpha,\ S_t \leq \beta\}$ or F_t is null when $\{S_t - I_t > c\}$ for some $c > 0$. We have been able to explicit the martingales M^F which come from (1) and to describe the law of the canonical process under the new probability measure Q_0^F. Then we apply these results to some kind of asymptotic Skorokhod embedding problem.

Tiziano Vargiolu (Università di Padova)

Optimal portfolio for HARA utility functions in a pure jump multidimensional incomplete market

In this paper we analyse a pure jump incomplete market where the risky assets can jump upwards or downwards. In this market we show that, when an investor wants to maximize a HARA utility function of his/her terminal wealth, his/her optimal strategy consists in keeping constant proportions of wealth in the risky assets, thus extending the classical Merton result to this market. We finally compare our results with the classical ones in the diffusion case in terms of scalar dependence of portfolio proportions on the risk-aversion coefficient.

This presentation is based on a joint work with Giorgia Callegaro (Scuola normale Superiore, Pisa).

Lioudmila Vostrikova (Université d'Angers)

On the stability of call/put option's prices in incomplete models under statistical estimations

We consider a semimartingale model for a risky asset $S = (S_t)_{t\geq 0}$ of the type

$$S_t = S_0 \exp(X_t)$$

where $X = (X_t)_{t\geq 0}$ is a semimartingale with the law depending on an unknown parameter $\theta,\ \theta \in \Theta$. The value process of the bond is supposed to be given by $B_t = \exp(rt)$ where r is a positive constant.

The classical procedure of pricing of call/put option of maturity T consists to choose the type of option, given by a continuous in the space $D([0,T[)$ functional and, then, one equivalent martingale measure Q belonging to the class of equivalent martingale measures, supposed non-empty, and put

$$\mathbb{C}_T(\theta) = \mathbb{E}_Q[\exp(-rt)g(S)]$$

Since the price depends on an unknown parameter we replace θ in the above expression by its estimator $\hat{\theta}$ which gives a new price $\mathbb{C}_T(\hat{\theta})$.

We prove inequalities for L^1-distance between $\mathbb{C}_T(\theta)$ and $\mathbb{C}_T(\hat{\theta})$ and we find conditions for the stability of prices under statistical estimation. We give also results for important particular case of Lévy processes. To illustrate the results, we apply them in the case of GVG and CGMY models.

Jeannette H.C. Wörner (Universität Göttingen)

Inference for stochastic volatility models: fine structure, market microstructure and jumps

In the recent years starting from the Black-Scholes model many different models either based on semimartingales, purely continuous, pure jump and a mixture of both, or fractional Brownian motion have been proposed in an attempt to capture the empirical findings of financial data.

Important issues in this area are the question of model selection, which of these classes of models is appropriate in a specific situation, especially if there is a jump component, how the fine structure and correlation structure of the data look like and how the volatility may be calculated for the different models. We will see that extensions of the well-known concept of quadratic variation may lead to answers to all of these questions.

In the following we will consider different classes of stochastic volatility models for the log-prices

$$X_t = Y_t + \int_0^t \sigma_s dB_s, \tag{1}$$

$$X_t = Y_t + \int_0^t \sigma_s dL_s, \tag{2}$$

$$X_t = Y_t + \int_0^t \sigma_s dB_s^H, \tag{3}$$

$$X_t = Y_t + \int_0^t \sigma_s dG_s, \tag{4}$$

where Y denotes some mean process, possibly including a jump component, σ denotes a volatility process, B a Brownian motion, L a pure jump Lévy process, B^H a fractional Brownian motion with Hurst parameter $H \in (0,1)$ and G a Gaussian process with stationary increments whose variance function of the increments locally around zero behaves like a fractional Brownian motion. Hence (2)-(4) may be viewed as generalizations of the classical Brownian motion based stochastic volatility model (1). (1) and (2) lie in the class of semimartingales whereas (3) and (4) in general do not, hence for these two models we will use pathwise Riemann-Stieltjes integrals instead of Itô integrals. With models (3) and (4) we may model long range dependence if $H \in (0.5,1)$ or a chaotic behavior if $H \in (0,0.5)$. For a long time fractional Brownian motion has been considered not to be appropriate for financial modelling since it allows for arbitrage. However, recently Guasoni et.al. (2007) have shown that when transaction costs are included also fractional Brownian motion might be considered to be a suitable model. Of course models of the form (1)-(4) may also be applied to other areas, especially climate and temperature modelling.

First of all we will give an overview how we can estimate the squared integrated volatility $\int_0^t \sigma_s^2 ds$ or more generally the p-th integrated volatility $\int_0^t \sigma_s^p ds$ in all four stochastic volatility models (cf. Barndorff-Nielsen and Shephard (2003), Barndorff-Nielsen et.al (2007, 2008), Corcuera et.al (2006), Woerner (2006a, 2007a)). We will use the concept of normed power variation $f(n,p)\sum_{i=1}^{[nt]} |X_{\frac{i}{n}} - X_{\frac{i-1}{n}}|^p$, where f is a suitable norming function which reflects the fine structure of the underlying process, and multipower variation where neighbouring increments are summed up. These are straight forward extensions of the concept of quadratic variation allowing to derive estimates which are more robust to additive components, especially jump components.

In a second part we will show how we can make use of the behaviour of the norming function f to infer the fine structure of stochastic volatility models, i.e. analyze the presents of a jump component and the Hölder continuity of a continuous component (cf. Woerner (2006b)). We will apply our theoretical results to high frequency financial data and see that on some days we can detect jumps, whereas on others the underlying process seems to be continuous.

Finally we briefly discuss problems occurring when looking at real high frequency data. The developed statistical theory implies that the estimates get better if the sampling frequency gets higher, i.e. the distance between the considered prices gets smaller. However, empirical studies have shown that when using tick-by-tick data or very high frequency data the realized volatility does not settle down to some limit, which should be the integrated volatility $\int_0^t \sigma_s^2 ds$, but increases.

One possibility to explain this finding is to introduce the concept of market microstructure or market friction, which means that due to effects of bid-ask bounces, discreteness of prices, liquidity problems and asymmetric information the observations of high frequency data possess an addition noise component which dominates the behaviour of the realized volatility. This leads to a modification of the model (1)

$$X_t = \int_0^t \sigma_s dB_s + \epsilon_t,$$

where ϵ denotes iid noise with mean zero (cf. Ait-Sahalia et.al (2005)). Another possibility is to use fractional Brownian motion based models (3) with Hurst parameter $H \in (0, 0.5)$. The idea behind explaining the empirical findings with this type of model is that by looking at non-normed power variation, we obtain as $n \to \infty$

$$\sum_{i=1}^{[nt]} \left| \int_{\frac{i-1}{n}}^{\frac{i}{n}} \sigma_s dB_s^H \right|^p \xrightarrow{p} \begin{cases} 0 & : \quad p > 1/H \\ \mu_{1/H} \int_0^t \sigma_s^{1/H} ds & : \quad p = 1/H \\ \infty & : \quad p < 1/H \end{cases} .$$

This implies that the behaviour of the empirical data may also be explained by a fractional Brownian motion based model with $H < 0.5$. In a first step we will look at the behaviour of power variation with $p = 2$ and $p = 4$ for various tick-by-tick data sets of Daimler Chrysler and Infinieon (cf. Woerner (2007b)). Indeed with increasing sampling frequency the quadratic variation increases but not as fast as predicted by the model with market microstructure, whereas for $p = 4$ the power variation even decreases which contradicts the behaviour of additional market microstructure, but may be explained by fractional Brownian motion based models.

Furthermore, we will construct a test statistic based on a combination of power and bipower variation with which we can test simultaneously for Brownian motion based models, Brownian motion based models with iid noise component and fractional Brownian motion based models. Looking at tick-by-tick data of Daimler Chrysler and Infineon we will see that this analysis gives evidence for fractional Brownian motion based model with $H < 0.5$ on this very fine time-scale.

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Yimin Xiao (Michigan State University)

Properties of strong local nondeterminism and local times of stable random fields

This talk is concerned with sample path properties of stable random fields. Under some general conditions, we establish results on uniform modulus of continuity, fractal dimensions and local times of stable random fields.

Uniform modulus of continuity The celebrated continuity theorems of Kolmorogov and Garsia (1972) provide uniform modulus of continuity for rather general stochastic processes and random fields. For Gaussian processes, a powerful chaining argument leads to much deeper results; see Talagrand (2006), Adler and Taylor (2007). Some of the results have been extended to non-Gaussian processes as long as the tail probabilities of the increments of the process decay fast enough [see Csáki and Csörgő (1992), Kwapień and Rosiński (2004)]. However, for general stable random fields, the aforementioned methods fail. The common way of getting a uniform modulus of continuity for stable random fields is based on the LePage representation and conditioning; see Marcus and Pisier (1984), Kôno and Maejima (1991a, 1991b), Biermé and Lacaux (2007).

We provide a general result on uniform modulus of continuity for random fields, which is a refinement of Kolmorogov's continuity theorem. Since our result does not assume exponential-type tail probabilities nor high moments, it is applicable to random fields with heavy-tailed distributions including the stable ones.

For every $n \geq 1$, let $D_n \subset [0,1]^N$ be the set of "dyadic points" of order n. Moreover, for every $\tau_n \in D_n$, let $O_{n-1}(\tau_n)$ denote the set of points in D_{n-1} that are neighbors of τ_n

Theorem 1. *Let $X = \{X(t), t \in [0,1]^N\}$ be a real-valued random field. Suppose $\sigma : \mathbb{R}_+ \to \mathbb{R}_+$ is a nondecreasing continuous function such that $\sigma(2h) \leq K\sigma(h)$ for some constant $K > 0$. If there exist constants $\gamma \in (0,1]$ and $\eta > 0$ such that $\lim_{h\to 0} \sigma(h)\big(\log 1/h\big)^{(1+\eta)/\gamma} = 0$ and*

$$\sum_{p=n}^{\infty} \mathbb{E}\bigg(\max_{\tau_p \in D_p} \max_{\tau'_{p-1} \in O_{p-1}(\tau_p)} \big|X(\tau_p) - X(\tau'_{p-1})\big|^{\gamma}\bigg) \leq \sigma(2^{-n})^{\gamma}. \tag{1}$$

Then X has a.s. continuous sample functions and for all $\varepsilon > 0$,

$$\lim_{h\to 0+} \frac{\sup_{t\in[0,1]^N} \sup_{d(s,t)\leq h} \big|X(t) - X(s)\big|}{\sigma(h)\,\big(\log 1/h\big)^{1/\gamma}\big(\log\log 1/h\big)^{(1+\varepsilon)/\gamma}} = 0, \qquad a.s. \tag{2}$$

Let $\{\xi_k, k \geq 1\}$ be a sequence of random variables such that, for some constants $\gamma > 0$ and $K > 0$, $\mathbb{E}\big(|\xi_k|^{\gamma}\big) = K$ for all $k \geq 1$. Let $M_n(\gamma) =$

$\mathbb{E}\big(\max_{1\le k\le n}|\xi_k|^\gamma\big)$. Then the maximal γ-moment (upper) index of $\{\xi_k, k\ge 1\}$ is defined by

$$\theta_\gamma = \limsup_{n\to\infty} \frac{\log M_n(\gamma)}{\log n}. \tag{3}$$

Corollary 2. *Let $X = \{X(t), t \in [0,1]^N\}$ be as in Theorem 1. We assume there exist constants $\gamma \in (0,1]$ and $H > 0$ such that for all $s,t \in [0,1]^N$*

$$\mathbb{E}\big(|X(s) - X(t)|^\gamma\big) \le K\,|s-t|^{H\gamma}. \tag{4}$$

Consider the normalized random variables

$$\frac{X(\tau_p) - X(\tau_p')}{\big[\mathbb{E}(|X(\tau_p) - X(\tau_p')|^\gamma)\big]^{1/\gamma}}, \qquad \forall \tau_p \in D_p,\ \tau_p' \in O_{p-1}(\tau_p) \ \text{ and all } p \ge 1, \tag{5}$$

and number them according to the order D_1, $D_2\backslash D_1, \ldots$ and denote the sequence by $\{\xi_k, k\ge 1\}$. If $\{\xi_k, k \ge 1\}$ has a maximal γ-moment index $\theta := \theta_\gamma$ and $H\gamma > \theta$, then for every $\varepsilon > 0$,

$$\limsup_{h\to 0+} \frac{\sup_{t\in[0,1]^N}\sup_{|s-t|\le h}\big|X(t)-X(s)\big|}{h^{H-\frac{\theta}{\gamma}-\varepsilon}} = 0, \qquad a.s. \tag{6}$$

Namely, $X(t)$ is uniformly Hölder continuous on $[0,1]^N$ of all orders $< H - \frac{\theta}{\gamma}$.

We present some results on maximal moment index of stable random variables and apply them to derive uniform modulus of continuity of stable random fields.

Fractal results for stable random fields Let $X = \{X(t), t \in \mathbb{R}^N\}$ be an (N, d, α)-stable random field defined by

$$X(t) = \big(X_1(t), \ldots, X_d(t)\big), \qquad t \in \mathbb{R}^N, \tag{7}$$

where $X_1, \ldots, X_d$ are independent copies of a real-valued stable random field X_0.

Many sample path properties of X can be determined by $\sigma(s,t) = \big\|X_0(s) - X_0(t)\big\|_\alpha$ $(s,t \in \mathbb{R}^N)$, the scalar parameter of the increment $X_0(s) - X_0(t)$.

Let $T \subseteq \mathbb{R}^N$ be an interval. We assume X_0 satisfies the following general conditions:

(S1). There exist positive constants $c_{2,1}$ and $c_{2,2}$ such that

$$c_{2,1} \le \rho(s,t) \le \sigma(s,t) \le c_{2,2}\,\rho(s,t) \quad \text{ for all } \ s,t \in T. \tag{8}$$

Here ρ is the metric on $\mathbb{R}^N$ defined by $\rho(s,t) = \sum_{j=1}^N |s_j - t_j|^{H_j}$ $\forall s,t \in \mathbb{R}^N$.

(S2). There exists a constant $c_{2,3} > 0$ such that for all integers $n \ge 2$ and all $t^1, \ldots, t^n \in T$,

$$\big\|X_0(t^n)\,\big|\,X_0(t^1), \ldots, X_0(t^{n-1})\big\|_\alpha \ge c_{2,3} \sum_{j=1}^N \min_{0\le k\le n-1} \big|t_j^n - t_j^k\big|^{H_j},$$

where $t_j^0 = 0$ for every $j = 1, \ldots, N$. That is, X_0 satisfies the (two-sided) sectorial local nondeterminism [see Xiao (2008)].

First we consider the fractal dimensions of the range $X([0,1]^N)$ and graph $\mathrm{Gr}X([0,1]^N) = \{(t, X(t)) : t \in [0,1]^N\}$. Without loss of generality, we assume from now on that

$$0 < H_1 \le H_2 \le \cdots \le H_N < 1. \tag{9}$$

The following extends some results in Ayache, Roueff and Xiao (2007b) for linear fractional stable sheets.

Theorem 3. *Let $X = \{X(t), t \in \mathbb{R}^N\}$ be an (N, d, α)-stable random field satisfying Condition (S1) on $T = [0,1]^N$ and having bounded sample functions. Then, with probability 1,*

$$\dim_{\mathrm{H}} X\big([0,1]^N\big) = \dim_{\mathrm{P}} X\big([0,1]^N\big) = \min\left\{d;\ \sum_{j=1}^{N} \frac{1}{H_j}\right\} \tag{10}$$

and

$$\begin{aligned}
&\dim_{\mathrm{H}} \mathrm{Gr}X\big([0,1]^N\big) = \dim_{\mathrm{P}} \mathrm{Gr}X\big([0,1]^N\big) \\
&\quad = \min\left\{\sum_{j=1}^{k} \frac{H_k}{H_j} + N - k + (1 - H_k)d,\ 1 \le k \le N;\ \sum_{j=1}^{N} \frac{1}{H_j}\right\} \\
&\quad = \begin{cases} \sum_{j=1}^{N} \frac{1}{H_j}, & \text{if } \sum_{j=1}^{N} \frac{1}{H_j} \le d, \\ \sum_{j=1}^{k} \frac{H_k}{H_j} + N - k + (1 - H_k)d, & \text{if } \sum_{j=1}^{k-1} \frac{1}{H_j} \le d < \sum_{j=1}^{k} \frac{1}{H_j}. \end{cases}
\end{aligned} \tag{11}$$

We will also discuss hitting probabilities and fractal dimension of the level sets.

Local times and their joint continuity Let $X(t)$ be a Borel vector field on $\mathbb{R}^N$ with values in $\mathbb{R}^d$. For any Borel set $T \subseteq \mathbb{R}^N$, the occupation measure of X on T is defined as $\mu_T(\bullet) = \lambda_N\big\{t \in T : X(t) \in \bullet\big\}$, which is a Borel measure on $\mathbb{R}^d$. If μ_T is absolutely continuous with respect to the Lebesgue measure λ_d, then $X(t)$ is said to have a *local time* on T. The local time, $L(\bullet, T)$, is defined as the Radon–Nikodým derivative of μ_T with respect to λ_d, i.e.,

$$L(x, T) = \frac{d\mu_T}{d\lambda_d}(x), \qquad \forall x \in \mathbb{R}^d.$$

In the above, x is called *space variable*, and T is the *time variable.* Usually, $L(x, [0,t])$ is written as $L(x,t)$.

We seek to answer the following questions: Given an (N, d, α)-stable random field X,

- when do local times exist?
- when is $L(x,t)$ continuous in $(x,t) \in \mathbb{R}^d \times \mathbb{R}^N$?

These questions are answered under Conditions (S1) and (S2). The following theorem extends the results in Nolan (1989), Ayache, Roueff and Xiao (2007a), as well as those in Xiao and Zhang (2002), Ayache, Wu and Xiao (2006) and Xiao (2007) for Gaussian random fields.

Theorem 4. *Let $X = \{X(t), t \in \mathbb{R}^N\}$ be an (N, d, α)-stable random field defined by (7) and suppose X_0 satisfies Condition (S1) on T. Then X has a local time $L(x, T) \in L^2(\mathbb{P} \times \lambda_d)$ if and only if $d < \sum_{j=1}^N 1/H_j$.*

If, in addition, X_0 satisfies Condition and (S2) on T, $1 < \alpha < 1$, and $d < \sum_{j=1}^N 1/H_j$. Then X has a jointly continuous local time on T.

An important technical tool for studying stable random fields is the various properties of strong local nondeterminism; see Xiao (2008).

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Martina Zähle (Universität Jena)

Stochastic partial differential equations with fractal noise

SPDEs on $\mathbb{R}^{n+1}$ are considered, where the noise is the formal time derivative of the spatial gradient of a random time-space vector field in $\mathbb{R}^k$. For the time derivatives we use fractional calculus in Banach spaces applied to the transition semigroups of the associated PDE.

The (stochastic) gradient is determined by means of Fourier analytic tools or stochastic forward-type integrals in the sense of Russo and Vallois. In this way we obtain pathwise solutions in fractional Sobolev spaces or certain stochastic variants. In particular, the above vector field may be an anisotropic fractional Brownian sheet with exponents greater than 1/2 or a Brownian field, respectively.

This presentation is based on a joint work with M. Hinz.

Jean-Claude Zambrini (Universidade de Lisboa)

Extrema with constraints in stochastic deformation of variational calculus

We shall consider a hierarchy of admissible constraints in the framework of a stochastic deformation of the classical calculus of variations. These constraints will take the form of expectations of functions or functionals of the process solving the original variational principle (i.e., a critical point of the conditional expectation of a functional of processes). Like in their classical counterparts, those problems are solved by the introduction of Lagrange multipliers. Various examples will illustrate our results. The proofs will involve the tools of stochastic analysis and various entropy principles.

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Sixth Seminar on Stochastic Analysis, Random Fields and Applications
May 19 - 23, 2008
Program summary

	Monday Auditorium	**Tuesday** Auditorium		**Wednesday** Auditorium		**Thursday** Auditorium	**Friday** Auditorium
08:30 - 08:40	*Opening*						
08:40 - 09:25	Schachermayer	Sircar	08:40 - 09:25	Xiao	08:40 - 09:25	Mattingly	Maslowski
09:30 - 09:55	Guasoni	Brummelhuis	09:30 - 09:55	Malyarenko	09:30 - 09:55	Romito	Mueller
09:55 - 10:20	Biagini	Vostrikova	09:55 - 10:20	Tindel	09:55 - 10:20	Cruzeiro	Sanz-Solé
10:40 - 11:25	Filipovic	Wörner	10:40 - 11:25	Albeverio	10:40 - 11:25	Stuart	Da Prato
11:30 - 11:55	Eberlein	Corcuera	11:30 - 11:55	Sturm	11:30 - 11:55	Zähle	Jakubowski
11:55 - 12:20	Carmona	Alos	11:55 - 12:20	Stannat	11:55 - 12:20	Nourdin	Deuschel
12:30 - 14:00	*Lunch*	*Lunch*	12:30 - 14:00	*Lunch*	12:30 - 14:00	*Lunch*	*Lunch*
14:10 - 14:55	Platen	Kyprianou	14:10 - 14:35	Barndorff-N.	14:10 - 14:55	Perkins	Cranston
15:00 - 15:25	Pham	Valkeila	14:40 - 15:05	Millet	15:00 - 15:25	Cerrai	Blanchard
15:25 - 15:50	Obloj	Dayanik			15:25 - 15:50	Rüdiger	Eisenbaum
			15:15 - 15:20	*Opening*			
			15:20 - 16:05	Imkeller			
16:20 - 16:45	Vargiolu	Tessitore			16:20 - 16:45	Roynette	Engelbert
16:50 - 17:15	Lescot	Buckdahn	16:45 - 17:05	On. Borradori	16:50 - 17:15	Vallois	Allouba
17:20 - 17:45	Ceci	Hongler	17:05 - 17:50	Romer	17:20 - 17:45	Lorinczi	Zambrini
17:50 - 18:15	Trutnau	Bally	17:55 - 18:40	Carmona	17:50 - 18:15	Mayer-Wolf	Gnedin
18:20 - 18:45		Utzet					
			18:45 - 19:45	*Aperitive*			
19:30	*Dinner*	*Dinner*	19:45	*Dinner*	19:30	*Dinner*	

Posters: Room Balint every day