# Abstracts

## Day 1, Oct. 26th

**Chair person** Yasushi Ishikawa

**13:10 - 14:00** Hideo Nagai
**14:05 - 14:55** Antoine Jacquier
**15:00 - 15:50** Jun Sekine
**16:10 - 17:00** Shuenn-jyi Sheu

## Hideo Nagai

**Robustness on large deviation estimates for controlled semi-martingales**

Motivated by downside risk minimization on the wealth process in an incomplete market model, we consider minimizing the probability that the empirical mean of a controlled semi-martingale falls below a certain level on a time horizon $T$, and then study the asymptotic behavior of the minimizing probability as $T \to \infty$. This asymptotic behavior relates to an risk-sensitive stochastic control problem in the risk-averse case. Indeed, we can obtain an expression of the decay rate of the probability by the Legendre transform of the limit value of the value function of the stochastic control problem, which is characterized as the solution to an H-J-B equation of ergodic type. After overviewing this asymptotic analysis we shall present the results on its robust version.

## Antoine, Jacquier

**Sharp large deviations and forward implied volatility**

Forward implied volatility is the implied volatility corresponding to forward-start options, namely European Call or Put options with payoff $\max(S(t+\tau)/S(t) - K, 0); t > 0$ is the (contractually fixed) forward-start date and $\tau$ the maturity of the contract. We investigate here the properties of the forward implied volatility, and in particular its asymptotic behaviour as the maturity tends to zero or becomes large. If its large-maturity asymptotic (as $\tau$ becomes large) does not depend much on the forward-start date $t$, its small-maturity behaviour ($\tau$ tending to zero) becomes very subtle. In order to study these behaviours, we make use of sharp large deviations techniques, based on the behaviour of the moment generating function of the stock price process. In passing, we highlight some non-trivial degenerate examples not covered by standard large deviations techniques (such as the Gartner-Ellis theorem). This is based on joint works with Patrick Roome.

## Jun Sekine

**Utility maximization with floor constraint**

After reviewing the problem and related works, a dual approach to the problem is introduced in a Markovian SDE model driven by Brownian motions. The free-boundary problem associated with the differential of the dual HJB equation plays an important role. The dual optimizer is constructed by the solution to an SDE with (nonsticky) reflection at the free-boundary. Using it, the solution to the primal utility maximization problem is recovered. The talk is based on a joint with Salvatore Federico (Univ. of Milano) and Fausto Gozzi (LUISS, Roma).

## Shuenn-jyi Sheu

**TBA**

# Day 2, Oct. 27th

**Chair person** Masayuki Uchida

**9:00 - 9:50** Naoto Kunitomo

**10:00 - 10:50** Yacine Ait-Sahalia

**11:00 - 11:50** Hiroki Masuda

**Chair person** Hideatsu Tsukahara

**14:05 - 14:55** Michael Sørensen

**15:00 - 15:50** Mark Podolskij

**16:10 - 17:00** B.L.S. Prakasa Rao

## Naoto Kunitomo

**The SIML Estimation of Integrated Covariance and Hedging Coefficients under Micro-market noise and Random Sampling**

For estimating the integrated volatility and covariance by using high frequency data, Kunitomo and Sato (2008, 2011) have proposed the Separating Information Maximum Likelihood (SIML) method when there are micro-market noises. The SIML estimator has reasonable finite sample properties and asymptotic properties when the sample size is large under general conditions. We shall show that the SIML estimation is useful for estimating the integrated covariance and hedging coefficients when we have micro-market noise and financial high frequency data are randomly sampled. The SIML estimation is consistent and has the stable convergence (i.e. the asymptotic normality in the deterministic case) and it has reasonable finite sample properties with these effects.

## Yacine Ait-Sahalia

**High Frequency Traders: Taking Advantage of Speed**

We propose a model of dynamic trading where a strategic high frequency trader receives an imperfect signal about future order flows, and exploits his speed advantage to optimize his quoting policy. We determine the provision of liquidity, order cancellations, and impact on low frequency traders as a function of both the high frequency trader's latency, and the market volatility. The model predicts that volatility leads high frequency traders to reduce their provision of liquidity. Finally, we analyze the impact of various policies designed to potentially regulate high frequency trading.

Joint work with Mehmet Saglam.

## Hiroki Masuda

**Multi-step estimation procedure for stable Ornstein-Uhlenbeck processes**

We consider estimation of a non-Gaussian stable Ornstein-Uhlenbeck process based on discrete-time infill sampling. We show that the asymptotic mixed normality holds true for the associated statistical experiments, and discuss how to construct a practical estimator in an easy way without much information loss. As for estimation of all the unknown parameters involved, we will propose a multistep estimation procedure, expected to result in a somewhat more stable performance compared with simultaneous optimization.

## Michael Sørensen

**Simulation of Diffusion Bridges with Application to Statistical Inference for Stochastic Differential Equations**

A simple method for simulating diffusion bridges is presented. A diffusion bridge is a solution to a stochastic differential equation in an interval, where the starting point and the end point are fixed. Diffusion bridges play a crucial role in simulation-based likelihood and Bayesian inference for stochastic differential equations. The new method consists in constructing a good approximation to a diffusion bridge from two diffusions, one moving forward in time, the other backward. These two basic diffusions can be simulated by a simple method like the Milstein scheme. The approximate diffusion bridge is then used as a proposal for a MCMC algorithm with exact diffusion bridges as the target distribution. The algorithm works particularly well for long time intervals, where other algorithms for simulation of diffusion bridges tend not to work. In fact, the computer time increases linearly with the length of the interval.

The usefulness of the new simulation method to likelihood inference for discretely sampled stochastic differential equations is demonstrated in a simulation study. The data can be viewed as incomplete observations from a model with a tractable likelihood function. Therefore a stochastic EM-algorithm or a Gibbs sampler can be used to obtain maximum likelihood estimates of the model parameters. The new algorithm for simulating diffusion bridges forms an essential part of the estimation method, where it is used to simulate the full hidden data given the observations.

The lecture is based on joint work with Mogens Bladt, Fernando Baltazar-Larios and Samuel Finch.

## Mark Podolskij

**A test for the rank of the volatility process: the random perturbation approach**

In this talk we present a test for the maximal rank of the matrix-valued volatility process in the continuous Ito semimartingale framework. Our idea is based upon a random perturbation of the original high frequency observations of an Ito semimartingale, which opens the way for rank testing. We develop the complete limit theory for the test statistic and apply it to various null and alternative hypotheses.

## B.L.S. Prakasa Rao

**Statistical inference for fractional diffusion processes**

There are some time series which exhibit long-range dependence as noticed by Hurst in his investigations of river water levels along Nile river. Long-range dependence is connected with the concept of self-similarity in that increments of a self-similar process with stationary increments exhibit long-range dependence under some conditions. Fractional Brownian motion is an example of such a process. We discuss statistical inference for stochastic processes modeled by stochastic differential equations driven by a fractional Brownian motion. These processes are termed as fractional diffusion processes. Since fractional Brownian motion is not a semimartingale, it is not possible to extend the notion of a stochastic integral with respect to a fractional Brownian motion following the ideas of Ito integration. There are other methods of extending integration with respect to a fractional Brownian motion. Suppose a complete path of a fractional diffusion process is observed over a finite time interval. We will present some results on inference for such processes. Some recent work on change-point problems will be discussed.

# Day 3, Oct. 28th

**Chair person** Arturo Kohatsu-higa

**9:00 - 9:50** Noufel Frikha

**10:00 - 10:50** Ahmed Kebaier

**11:00 - 11:50** Antoine Lejay

**Chair person** Josef Teichmann

**14:05 - 14:55** Klaus Ritter

**15:00 - 15:50** Paul Gassiat

**16:10 - 17:00** Kyong-Kuk Kim

## Noufel Frikha

**Multi-level stochastic approximation algorithms**

During this presentation we study multi-level stochastic approximation algorithm. Our aim is to extend the scope of the multi-level Monte Carlo method recently introduced by Giles (Giles 2008) to the framework of stochastic optimization by means of stochastic approximation algorithm. We first introduce and study a two-level method, also referred as statistical romberg stochastic approximation algorithm. Then, its extension to multi-level is proposed. We prove a central limit theorem for both methods and describe the possible optimal choices of step size sequence. Numerical results confirm the theoretical analysis and show a significant reduction in the initial computational cost.

## Ahmed Kebaier

**The Adaptative Multilevel Monte Carlo method**

The efficiency of Monte Carlo simulations is significantly improved when implemented with variance reduction methods. Among these methods we focus on the popular importance sampling technique based on producing a parametric transformation through a shift parameter $\theta$. The optimal choice of $\theta$ is approximated using Robbins-Monro procedures, provided that a non explosion condition is satisfied.

In the First part of the talk, we introduce a new algorithm based on a combination of the Multilevel Monte Carlo method and the importance sampling technique. In the setting of discritized diffusions, the Multilevel Monte Carlo method is known for reducing efficiently the complexity compared to the classical Monte Carlo one. We prove the almost sure convergence of both constrained and unconstrained versions of the Robbins-Monro routine, towards the optimal shift $\theta^*$ that minimizes the variance associated to the Multilevel Monte Carlo. Then, we prove a central limit theorem for the new algorithm that we called adaptative Multilevel Monte Carlo method.

In the second part of the talk we extend the above procedure in the case when no discretizing scheme is used. More precisely, we introduce a new algorithm reducing both variance and computational effort associated to the effective computation of option prices when the underlying asset process follows an exponential pure jump Lévy model.

## Antoine Lejay

**Simulation of SDE with discontinuous drift.**

From a joint work with A. Kohatsu-Higa and K. Yasuda

We discuss an approach to estimate upper bounds for the weak rate of convergence of the Euler scheme in presence of a discontinuous drift, when the coefficient is regularized. The idea was to use a kind of perturbation formula and to "separate" the approximations into several effects: approximation of the drift, regularity of the terminal conditions, ... While there have been a few works on the weak rate of convergence in presence of discontinuous drifts, we show by mixing several arguments (PDE, Malliavin calculus, stochastic analysis, ...) that various rates may be achieved in function of the context.

## Klaus Ritter

**Multi-level Monte Carlo for Approximation of Distribution Functions and an Application to $AF^4$**

The multi-level Monte Carlo approach is a powerful variance reduction technique, which is applied, in particular, in the context of SDEs. While the standard task is to compute the expectation of a real-valued functional, we discuss how to approximate a distribution or density function on a compact interval in this talk. We establish upper bounds for the error of suitable multi-level algorithms. Moreover, we briefly discuss an application to asymmetric flow field flow fractionation ($AF^4$), which involves exit times of reflected diffusions.

Joint work with Mike Giles (Oxford Univ.), Oleg Iliev (Fraunhofer ITWM, Kaiserslautern), and Tigran Nagapetyan (Fraunhofer ITWM, Kaiserslautern).

## Paul Gassiat

**Stochastic control with rough paths**

We study a class of controlled rough differential equations. It is shown that the value function satisfies a HJB type equation; we also establish a form of the Pontryagin maximum principle. Deterministic problems of this type arise in the duality theory for controlled diffusion processes and typically involve anticipating stochastic analysis. We propose a formulation based on rough paths and then obtain a generalization of Roger's duality formula [L. C. G. Rogers, 2007] from discrete to continuous time. We also make the link to old work of [Davis–Burstein,1992].

## Kyoung-Kuk Kim

**Simulation of tempered stable Lévy bridges and its applications**

In this work, we consider tempered stable Lévy subordinators and develop bridge sampling methods. An approximate conditional PDF is derived for processes with stable index less than one, using the double saddle-point approximation, and an acceptance-rejection algorithm is proposed. Then, we extend the result to two sided tempered stable processes, e.g., finite variation CGMY processes. The proposed sampling method is applied to the pricing of path-dependent options under subordinated Brownian motion models and to the statistical inference for discretely observed Lévy processes. (joint work with Sojung Kim)

# Day 5, Oct. 30th

**Chair person** Takahiro Aoyama

**9:00 - 9:50** Makoto Maejima

**10:00 - 10:50** Konstantin Borovkov

**11:00 - 11:50** Takahiko Fujita

**Chair person** Makoto Yamazato

**14:05 - 14:55** Takaaki Shimura

**15:00 - 15:50** Alexander Novikov

**16:10 - 17:00** Thomas Simon

## Makoto Maejima
**Generalized Gamma Convolutions**

Generalized Gamma Convolutions A probability distribution $\mathbb{R}_+$ is called generalized gamma convolution (GGC) if it is the weak limit of finite convolutions of gamma distributions. GGCs were introduced and used to prove the infinite divisibility of the Pareto distribution and of the log- normal distribution by Thorin(1977, two papers). GGCs are also selfdecomposable and thus infinitely divisible, and the class of GGCs is called the Thorin class, denoted by $T(\mathbb{R}_+)$. This class is surprisingly rich.

This class was extended to $\mathbb{R}^d$ by Barndorff-Nielsen-M.-Sato (2006) as follows: Call $\Gamma x$ an elementary gamma random variable in $\mathbb{R}^d$ if $x$ is a non-random non-zero vector in $\mathbb{R}^d$ and $\Gamma$is a gamma random variable on $\mathbb{R}_+$. Then the Thorin class on $\mathbb{R}^d$, denoted by $T(\mathbb{R}^d)$, is defined as the smallest class of distributions on $\mathbb{R}^d$ that contains all elementary gamma distributions on $\mathbb{R}^d$ and is closed under convolution and weak convergence.(The Thorin class $T(\mathbb{R})$ is already defined in Thorin (1978) as the name of the extended generalized gamma convolutions (EGGC).) The class $T(\mathbb{R}^d)$ can be characterized in many ways.

In the first part of this talk, I will explain some theoretical aspects of the Thorin class, and then in the second part I will discuss examples of GGCs and EGGCs which appeared in some quite different problems.

## Konstantin Borovkov
**Fourier transform and Options Pricing**

Over the last decade, several authors have successfully used Fourier inversion to price options in situations where alternative methods proved to be much less efficient. We will give an overview of the approaches used and results that were obtained in that direction, and discuss some further advances.

## Takahiko Fujita
**TBA**

## Takaaki Shimura
**A numerical characteristic of extreme values**

A numerical characteristic of large random numbers is studied. Let $F$ be a distribution on the real numbers with infinite endpoint. $X$ denotes a random variable with distribution $F$. Consider the transformation for a decimal number $d_1d_2d_3\dots d_n.d_{n+1}\dots$ in $[10^{n-1}, 10^n)$ to $0.d_2d_3\dots$ in $[0, 1)$. We are interested in the distribution of transformed $X$ for large $X$, which implies the behavior of the large random number except the first figure. It is shown that the distribution of transformed $X$ conditioned by the first figure converges as $X$ becomes large for most distributions. Moreover, it turns out that the limit distribution depends on the tail behavior of $F$ and the first figure. A numerical characteristic of small random numbers which mean the distances between the random numbers and its finite endpoint is also investigated.

## Alexander Novikov

**Lower and upper bounds for Asian-type options: a unified approach**

In the context of dealing with financial risk management problems it is desirable to have accurate bounds for option prices in situations when pricing formulae do not exist in the closed form. A unified approach for obtaining upper and lower bounds for Asian-type options (including basket options) is proposed in this talk. The bounds obtained are applicable to the continuous and discrete-time frameworks for the case of time-dependent interest rates. Numerical examples will be provided to illustrate the accuracy of the bounds.

Joint work with Nino Kordzakhia (Macquarie University, Sydney, Australia).

## Thomas Simon

**On the distributional theory of stable laws**

Stable laws on the line are classical objects which appear in many problems of probability theory. In this talk we will deal with the shape of their densities, in the spirit of Zolotarev's book. We are interested in the following topics: unimodality, bell-shape, mean-median-mode inequality, perfect skewness, stochastic orders. Our main tools are different additive or multiplicative factorizations for the positive stable laws. Several open problems will be also discussed.

# Day 6, Oct. 31st

**Chair person** Antoine Jacquier

**9:00 - 9:50** Josef Teichmann

**10:00 - 10:50** Oleg Reichmann

**11:00 - 11:50** Christa Cuchiero

**Chair person** Jun Sekine

**14:05 - 14:55** Andrea Macrina

**15:00 - 15:50** Harald Oberhauser

**16:10 - 17:00** Jim Gatheral

## Josef Teichmann

**Bond markets beyond short rate paradigms**

We investigate default-free bond markets where the standard relationship between a possibly existing bank account process and the term structure of bond prices is broken, i.e. the bank account process is not a valid numéraire. We argue that this feature is not the exception but rather the rule in bond markets when starting with, e.g., terminal bonds as numéraires. Our setting are general càdlàg processes as bond prices, where we employ directly methods from large financial markets. Moreover, we do not restrict price process to be semimartingales, which allows for example to consider markets driven by fractional Brownian motion. In the core of the article we relate the appropriate no arbitrage assumptions (NAFL), i.e. no asymptotic free lunch, to the existence of an equivalent local martingale measure with respect to the terminal bond as numéraire, and no arbitrage opportunities of the first kind (NAA1) to the existence of a supermartingale deflator, respectively. In all settings we obtain existence of a generalized bank account as a limit of convex combinations of roll-over bonds. Additionally we provide an alternative definition of the concept of a numéraire, leading to a possibly interesting connection to bubbles. If we can construct a bank account process through roll-overs, we can relate the impossibility of taking the bank account as numéraire to liquidity effects. Here we enter endogenously the arena of multiple yield curves. The theory is illustrated by several examples. (joint work with Irene Klein and Thorsten Schmidt)

## Oleg Reichmann

**Efficient PDE methods for multivariate option pricing**

We consider the numerical approximation of Kolmogorov equations arising in the context of option pricing under Lévy models and beyond in a multivariate setup. The existence and uniqueness of variational solutions of the partial integrodifferential equations (PIDEs) is established in Sobolev spaces of fractional or variable order. Most discretization methods for the considered multivariate models suffer from the curse of dimension which impedes an efficient solution of the arising systems. We tackle this problem by the use of sparse discretization methods such as classical sparse grids or tensor train techniques. Numerical examples in multiple space dimensions confirm the efficiency of the described methods.

## Christa Cuchiero

**AN HJM APPROACH FOR MULTIPLE YIELD CURVES**

We consider modeling of multiple yield curves, which emerged in the course of the financial crisis due to credit and liquidity risk of the interbank sector. More precisely, we provide an HJM approach for modeling the term structure of multiplicative spreads between the riskfree forward prices (derived from OIS rates) and the risky forward prices (obtained from forward rate agreements and swaps whose underlyings are Libor rates). We specify in particular the HJM drift condition and consider conditions which ensure that the multiplicative spreads are greater than 1. This framework allows to unify and extend several approaches which have been proposed in literature in the context of multiple curve modeling, for instance, the Lévy driven HJM model studied by Crepey et al. [1, 2] can be recovered. When the driving process of both the riskfree forward rate and the spread is specified to be affine, we obtain a Markovian

structure which allows for simple pricing formulas of LIBOR interest rate derivatives. The talk is based on joint work with Claudio Fontana and Alessandro Gnoatto.

References
[1] S. Crépey, Z. Grbac and H. N. Nguyen. A multiple-curve HJM model of interbank risk. Mathematics and Financial Economics, 6(3): 155-190, 2012.
[2] S. Crépey, Z. Grbac, H. N. Nguyen and D. Skovmand. A multiple-curve CVA interest rate model. Working paper

## Andrea Macrina

**TBA**

## Harald Oberhauser

**From the Skorokhod embedding problem to the generation of Brownian increments**

An intuitive solution of the Skorokhod embedding problem (SEP) was given by D.H. Root in 1969 who proved the existence of a subset of time-space such that its first hitting time by time-space Brownian motion solves the SEP. Applications in robust pricing led recently to a revived interest in this solution. Unfortunately, Root's existence proof was not constructive and the task is to identify this subset for a given probability measure. I will report about new and efficient methods to compute this set, give applications of the SEP to Monte-Carlo and to rough path schemes. Joint work with with P. Gassiat (TU Berlin) and A. Mijatovic (Imperial College).

## Jim Gatheral

**Fast Ninomiya-Victoir calibration of the Double-Mean-Reverting Model**

We consider the three factor double mean reverting (DMR) model, a model which can be successfully calibrated to both VIX options and SPX options simultaneously. One drawback of this model is that calibration may be slow because no closed form solution for European options exists. In this talk, we apply modified versions of the second order Monte Carlo scheme of Ninomiya and Victoir and compare these to the Euler-Maruyama scheme with full truncation of Lord et al., demonstrating on the one hand that fast calibration of the DMR model is practical, and on the other that suitably modified Ninomiya-Victoir schemes are applicable to the simulation of much more complicated time-homogeneous models than may have been thought previously.

# Day 7, Nov. 1st

**Chair person** Jiro Akahori

**9:00 - 9:50** István Gyöngy

**10:00 - 10:50** Hideatsu Tsukahara

**11:00 -** Young Researchers Session (Yuri Imamura, Libo Li, Ogiwara Teppei)

## István Gyöngy

**TBA**

## Hideatsu Tsukahara

**Estimating and Backtesting Distortion Risk Measures**

We have shown in our previous work that for a wide class of distortion functions, it is possible to construct an estimator for distortion risk measures (DRMs) with reasonable accuracy based on weakly dependent data. In this presentation, we first show that the estimator always has a negative bias and illustrate a bootstrap-based method for bias correction. The method will be shown to possess consistency under certain regularity conditions.

For a Monte Carlo simulation study, we consider a stochastic volatility (SV) model with inverse gamma AR(1) volatility process. Simulation results for estimating Value-at-Risk, expected shortfall and proportional odds risk measure under various values of the parameters show that the normal approximation, our asymptotic variance estimation and bias correction methods are working to a reasonable extent.

As a next step in financial risk management, we need to evaluate the accuracy of the model and/or estimation procedure for risk measurement. To this end, simple backtesting procedures will be proposed for DRMs which can be made theoretically rigorous with i.i.d. data. We can also implement the conditional approach by McNeil and Frey with GARCH-type observations. Simulation results with GARCH(1,1) setting will be presented; it seems to show advantage of the conditional approach. Backtestability is the latest issue on DRMs, and we discuss it if time allows.

# Young Researchers Session

**Yuri Imamura; An Asymptotic Static Hedge of a Timing Risk and its Error**

In the talk, we discuss how a risk associated with a stopping time, which we call a generalized timing risk, could be hedged by a static position of European path-independent options. Timing risk is a risk of uncertain dividend, especially of its payment time. P. Carr and J. Picron (1999) tried to apply the semi-static hedging formula of barrier options to hedge a payment at a stopping time in a Black-Scholes environment. In this study, we show that an asymptotic static hedge of a generalized timing risk in a general diffusion model is possible, and then we give an error estimate of the asymptotic static hedge of a generalized timing risk.

**Libo Li; Parametrix approach to the transition density of SDEs driven by $\alpha$-stable Lévy process with Hölder continuous coefficients**

The transition density of stochastic differential equations driven by $\alpha$-stable Lévy process with Hölder continuous coefficients have been recently studied by Debussche and Fournier, where they showed the existence of the transition density. From a simulation point of view, the draw back is that it is only an existence result. In our work, under some slightly weaker assumptions, we apply the parametrix method originated from theory of PDE, to derive an asymptotic representation of the transition density, in addition, we show that the transition density is jointly continuous and once differentiable with respect to the initial condition.

**Teppei Ogiwara; LAMN property and asymptotically efficient estimation for nonsynchronously observed diffusion processes**

We study the LAMN property for a statistical model generated by nonsynchronously observed diffusion processes. We also show that the quasi-maximum likelihood estimator and the Bayes type estimator proposed in Ogihara and Yoshida (2012) are asymptotically efficient. The problem of nonsynchronous observations appears when we estimate the covariation of security returns using high-frequency data in financial markets. A family of probability measures are said to have the local asymptotic mixed normality (LAMN) property if local log-likelihood ratios are asymptotically quadratic with a specific form. This property is significantly related to asymptotic efficiency. Jeganathan (1983) gave an asymptotic lower bound of a risk function of estimation errors under the LAMN property. If some estimator attains this lower bound, we can say that the estimator is asymptotically efficient. To obtain the LAMN property for general diffusion processes, Malliavin calculus techniques are useful. Gobet (2001) proved the LAMN property for a family of probability measures generated by a synchronous, equi-spaced sampling scheme by using these techniques. We use Malliavin calculus techniques and introduce a family of stochastic processes which *connect* the original diffusion process to the Euler-Maruyama approximation. Then we prove a limit theorem of the Euler-Maruyama type quasi-log-likelihood ratio to obtain the LAMN property.