# Stochastic Analysis and Its Applications XV
## Room Praktikum (First Floor)
## KPMS MFF UK, Sokolovska 83, Praha 8
## January 4, 2019
# Program

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9:30 – 10:00: Arrival, Coffee

10:00 – 10:45
**Jan Swart**, Anja Sturm, Rongfeng Sun, and Jinjiong Yu
Interface tightness

10:45 – 11:30
**Josef Kurka,** Jozef Baruník
Horizon-specific risks, higher moments, and asset prices

11:30 – 12:00
**Matěj Nevrla,** Jozef Baruník
Tail risks, asset prices, and investment horizons

12:00 – 13:30: Lunch Break

13:30 – 14:15:
**Jan Pospíšil**
Fitting NURBS to financial curves

14:15 – 15:00:
**Jan Večeř**
Dynamic scoring: Probabilistic model selection based on utility maximization

15:00 – 15:45:
**Petr Čoupek,** Tyrone E. Duncan, Bozenna Pasik-Duncan
On the Itô formula for Rosenblatt processes

15:45 – 16:00: Coffee Break

16:00 – 16:45:
Jiří Hozman, **Tomáš Tichý,** Michal Holčapek
Modern numerical methods: from Black-Scholes model to advanced option pricing

16:45 – 17:30:
**Petr Dostál**
Almost optimal trading strategies for small proportional transaction costs

17:30– 17:50:
**Vít Kubelka**
Kalman - Bucy filter in the space of continuous functions

18:00: Dinner

# Abstracts

**Jan Swart**, Anja Sturm, Rongfeng Sun, and Jinjiong Yu

Interface tightness

A one-dimensional interacting particle system is said to exhibit interface tightness if starting in an initial condition describing the interface between two constant configurations of different types, the process modulo translations is positive recurrent. In a biological setting, this describes two populations that do not mix, and it is believed to be a common phenomenon in one-dimensional particle systems. The mathematical study of this phenomenon started with the work of Cox en Durrett, who in 1995 proved it for long-range voter models. I will discuss an alternative proof technique that has recently successfully been applied to biased voter models, and at the end also mention some open problems.

**Josef Kurka,** Jozef Baruník

Horizon-specific risks, higher moments, and asset prices

Asset pricing traditionally works with information aggregated over horizons, however investors' preferences are horizon-specific. Decomposing returns, and risk factors to components representing individual horizons may hence provide valuable insights into pricing mechanisms of investors. With increasing size of factor-investing literature, the number of factors approximating risk, and possibly explaining the cross section of returns is growing rapidly. However, most of the factors perform poorly in subsequent out-of-sample testing. Therefore, attention should be turned to theory-based factors approximating the risks such as moments of the return distribution that are found to be priced empirically. We derive an asset pricing model that contains second, third and fourth centralized moments of returns on aggregate wealth decomposed to short-run and long-run components. Empirical results show that horizon-specific risk from higher moments is priced, and uncover different effects of the moment-based risk factors in short-run, and long-run.

**Matěj Nevrla,** Jozef Baruník

Tail risks, asset prices, and investment horizons

The aim is to examine how extreme market risks are priced in the cross-section of asset returns at various horizons. Based on the frequency decomposition of covariance between indicator functions, we define the quantile cross-spectral beta of an asset capturing tail-specific as well as horizon-, or frequency-specific risks. Further, we work with two notions of frequency-specific extreme market risks. First, we define tail market risk that captures dependence between extremely low market as well as asset returns. Second, extreme market volatility risk is characterized by dependence between extremely high increments of market volatility and extremely low asset return. Empirical findings based on the datasets with long enough history, 30 Fama-French Industry portfolios, and 25 Fama-French portfolios sorted on size and

book-to-market support our intuition. Results suggest that both frequency-specific tail market risk and extreme volatility risks are significantly priced and our five-factor model provides an improvement over specifications considered by previous literature.

**Jan Pospíšil**

Fitting NURBS to financial curves

In this talk we show how non-uniform rational B-splines (NURBS) can be fitted to typical financial curves such as payoff functions, pricing formulas and implied volatilities. To demonstrate the advantages of NURBS, we show how they can be fitted to smooth, non-smooth or even discontinuous financial curves easily and how rationality of NURBS give us much greater flexibility (compared to the standard B-splines) in describing complicated solutions of pricing equations of stochastic volatility jump-diffusion models.

**Jan Večeř**

Dynamic scoring: Probabilistic model selection based on utility maximization

We propose a novel approach of model selection for probability estimates that may be applied in time evolving setting. Specifically, we show that any discrepancy between different probability estimates opens a possibility to compare them by trading on a hypothetical betting market that trades probabilities. We describe the mechanism of such a market, where agents maximize some utility function which determines the optimal trading volume for given odds. This procedure produces supply and demand functions, that determine the size of the bet as a function of a trading probability. These functions are closed form for the choice of logarithmic and exponential utility functions. Having two probability estimates and the corresponding supply and demand functions, the trade matching these estimates happens at the intersection of the supply and demand functions. We show that an agent using correct probabilities will realize a profit in expectation when trading against any other set of probabilities. The expected profit realized by the correct view of the market probabilities can be used as a measure of information in terms of statistical divergence.

**Petr Čoupek,** Tyrone E. Duncan, Bozenna Pasik-Duncan

On the Itô formula for Rosenblatt processes

Rosenblatt processes arise naturally as limits of sums of strongly correlated random variables in the so-called non-central limit theorems. They comprise a family of continuous stochastic processes that exhibit self-similarity and long-range dependence but, contrary to fractional Brownian motions, they are not Gaussian. The talk will be devoted to elements of stochastic calculus for Rosenblatt processes and to a general Itô-type formula for processes with second-order fractional (Rosenblatt) stochastic differential.

Jiří Hozman, **Tomáš Tichý,** Michal Holčapek

Modern numerical methods: from Black-Scholes model to advanced option pricing

Option pricing is an essential issue of modern theory of financial engineering. This presentation aims to acquaint the audience with the methodological concepts of three relatively novel different numerical techniques when applied to the option pricing problem described by PDEs. As the motivation, the first part is devoted to a general introduction and a mutual comparison of discontinuous Galerkin methods, wavelets and fuzzy transform techniques within the simple BS framework. The extensive numerical benchmark with real market data and sensitivity measurement is provided. The second part presents how to proceed when some generalization of BS framework is assumed. Specifically, we propose a numerical technique based on the discontinuous Galerkin method for a general one-factor stochastic volatility model for the pricing of European options. The performance of this numerical procedure is documented using reference experiments on the several famous stochastic volatility models.

**Petr Dostál**

Almost optimal trading strategies for small proportional transaction costs

We consider a non-consuming agent facing small proportional transaction costs, interested in the wealth far in the future. The first considered case is when the investor wants to maximize the long run growth rate of the wealth process, which corresponds to the logarithmic utility function. For this case we derive a strategy that is almost optimal. It means that the rate of exponential growth of its wealth process is not less than the one of any other admissible strategy up to some small error. If the investor is more risk averse, we offer some modified strategy, which plays a similar role as the one above, but it (in a certain sense) corresponds to a power utility function unbounded from below.

**Vít Kubelka**

Kalman - Bucy filter in the space of continuous functions

The Kalman-Bucy Filter is a continuous time counterpart to the discrete time linear Kalman Filter. Therefore, it deals with dynamical system described by stochastic differential equations. First, the continuous time linear filtering problem in finite - dimensional space will be introduced. Afterwards, an extension for signal with values in the space of continuous functions and finite - dimensional observation process will be shown and some interesting examples will be discussed, e.g. the signal processes described by linear stochastic partial differential equations driven by Fractional Brownian motion.