# VCMF Educational Workshop

WU Vienna, Thu-Fri, September 12-13, 2019

**Room A,** Building D5, ground floor (D5.0.001)
**Mensa Cafeteria**, D1/TC - Teaching Center, ground floor

## Thursday, September 12, 2019

### Room A

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|---|---|
| 8:30 – 9:00 | Registration |
| 9:00 – 9:10 | Welcome Address |
| 9:10 – 10:40 | Julien **Guyon** (Bloomberg, Columbia Univ., New York Univ.)<br>**The Particle Method for Smile Calibratio**n<br>(part 1) |
| 10:40 – 11:10 | Coffee Break |
| 11:10 – 12:40 | Julien **Guyon** (Bloomberg, Columbia Univ., New York Univ.)<br>**The Particle Method for Smile Calibration**<br>(part 2) |
| 12:40 – 14:00 | Lunch Break in Mensa Cafeteria |
| 14:00 – 15:30 | Luitgard A. M. **Veraart** (London School of Economics)<br>**Systemic risk in financial networks**<br>(part 1) |
| 15:30 – 16:00 | Coffee Break |
| 16:00 – 17:30 | Huyên **Pham** (University Paris VII Diderot)<br>**Control of McKean-Vlasov systems and applications**<br>(part 1) |

# VCMF 2019 – Workshop

WU Vienna, Thu-Fri, September 12-13, 2019

## Friday, September 13, 2019

### Room A

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|---|---|
| 9:00 – 10:30 | Huyên **Pham** (University Paris VII Diderot)<br>**Control of McKean-Vlasov systems and applications**<br>(part 2) |
| 10:30 – 10:50 | Coffee Break |
| 10:50 – 12:20 | Luitgard A. M. **Veraart** (London School of Economics)<br>**Systemic risk in financial networks**<br>(part 2) |
| 12:20 – 13:30 | Lunch Break in Mensa Cafeteria |
| 13:30 – 15:00 | Josef **Teichmann** (ETH Zurich)<br>**The role of randomness in deep learning**<br>(part 1) |
| 15:00 – 15:20 | Coffee Break |
| 15:20 – 16:50 | Josef **Teichmann** (ETH Zurich)<br>**The role of randomness in deep learning**<br>(part 2) |

Invited lecture: Thu, 9:10-10:40 and Thu, 10:40-12:40, room A

Julien **Guyon** (Bloomberg, Columbia Univ., New York Univ.)

**The Particle Method for Smile Calibration**

The calibration of models to market smiles is a crucial issue for risk management in finance. This used to be done by running time-consuming optimization routines. In this short course we will show how particle methods very efficiently solve a wide variety of smile calibration problems, without resorting to any optimization:

- Calibration of the local volatility model with stochastic interest rates
- Calibration of stochastic local volatility models, possibly with stochastic interest rates and stochastic dividend yield
- Calibration to the smile of a basket of multi-asset local volatility-local correlation models, possibly with stochastic volatility, stochastic interest rates, and stochastic dividend yields
- Calibration of path-dependent volatility models and path-dependent correlation models
- Calibration of cross-dependent volatility models

The particle method is a Monte Carlo method where the simulated asset paths interact with each other so as to ensure that a given market smile (or several of them) is fitted. PDE methods typically do not work for these high-dimensional models. The particle method is not only the first available exact simulation-based method for smile calibration. It is also robust, easy to implement, and fast (as fast as a standard Monte Carlo algorithm), as many numerical examples will show. As of today, it is the most powerful tool for solving smile calibration problems. Icing on the cake: there are nice mathematics behind the scenes, namely the theory of McKean stochastic differential equations, propagation of chaos, and a new Malliavin «disintegration by parts» formula.

**Short Bio of Julien Guyon:**

Julien Guyon is a senior quantitative analyst in the Quantitative Research group at Bloomberg L.P., New York. He is also an adjunct professor in the Department of Mathematics at Columbia University and at the Courant Institute of Mathematical Sciences, NYU. Before joining Bloomberg, Julien worked in the Global Markets Quantitative Research team at Societe Generale in Paris for six years (2006-2012), and was an adjunct professor at Universite Paris 7 and Ecole des ponts. He co-authored the book Nonlinear Option Pricing (Chapman & Hall, CRC Financial Mathematics Series, 2014) with Pierre Henry-Labordere. His main research interests include nonlinear option pricing, volatility and correlation modeling, and numerical probabilistic methods. Julien holds a Ph.D. in Probability Theory and Statistics from Ecole des ponts. He graduated from Ecole Polytechnique (Paris), Universite Paris 6, and Ecole des ponts. A big soccer fan, Julien has also developed a strong interest in sports analytics, and has published several articles on the FIFA World Cup, the UEFA Champions League, and the UEFA Euro in top-tier newspapers such as The New York Times, Le Monde, and El Pais, including a new, fairer draw method for the FIFA World Cup.

Invited lecture: Thu, 16:00-17:30 and Fri, 17:30-10:30, room A

Huyên **Pham** (University Paris VII Diderot)

**Control of McKean-Vlasov systems and applications**

This lecture is concerned with the optimal control of McKean-Vlasov equations, which has been knowing a surge of interest since the emergence of the mean-field game theory. Such control problem corresponds to the asymptotic formulation of a N-player cooperative game under mean-field interaction, and can also be viewed as an influencer strategy problem over an interacting large population. It finds various applications in economy, finance, or social sciences for modelling motion of socially interacting individuals and herd behavior. It is also relevant for dealing with intermittence questions arising typically in risk management.

In the first part, I will focus on the discrete-time case, which extends the theory of Markov decision processes (MDP) to the mean-field interaction context. We give an application with explicit results to a problem of targeted advertising via social networks.

The second part is devoted to the continuous-time framework. We shall first consider the important class of linear-quadratic McKean-Vlasov (LQMKV) control problem, which provides a major source for examples and applications. We show a direct and elementary method for solving explicitly LQMKV based on a mean version of the well-known martingale optimality principle in optimal control, and the completion of squares technique. Variations and extensions to the case of infinite horizon, random coefficients and common noise are also addressed. We illustrate our results with an application to a robust mean-variance portfolio selection problem. Next, we present the dynamic programming approach (in other words, the time consistency approach) for the control of general McKean-Vlasov dynamics. In particular, we introduce the recent mathematical tools that have been developed in this context : differentiability in the Wasserstein space of probability measures, Itô formula along a flow of probability measures and Master Bellman equation. Extensions to stochastic differential games of McKean-Vlasov type are also discussed.

**Affiliations of Huyên Pham:**

- Professor, University Paris VII Diderot
- Laboratoire de Probabilités, Statistique et Modèlisation (LPSM)
- Senior research fellow at CREST (Center for Research in Economics and Statistics) - ENSAE (Grande École for Data Science, Economics, Finance and Actuarial science)
- Chair of Applied Mathematics, John von Neumann Institute, Vietnam National University

In 2007 he was awarded the Louis Bachelier Prize of the Natixis Foundation for Quantitative Research and the Société de Mathématiques Appliquées et Industrielles (SMAI) by the French Academy of Sciences.

Invited lecture: Fri, 13:30-15:00 and Fri, 15:00-16:50, room A

Josef **Teichmann** (ETH Zurich)

**The role of randomness in deep learning**

We consider (recurrent) deep neural networks from the point of view of controlled differential equations and develop a mathematical theory which explains the role of random initializations in learning procedures. Concepts from differential geometry and random projections meet in a surprising way.
This is based on joint works with Christa Cuchiero, Lukas Gonon, Martin Larsson, Lyudmilla Grigoryeva and Juan-Pablo Ortega.

**Short Bio of Josef Teichmann:**

Josef Teichmann - an Austrian mathematician - is professor for Financial Mathematics at ETH Zürich since 2009.

In 2006 he received the "START-Preis" of the Austrian Science Fund (FWF) - the highest Austrian award for young scientists of any discipline.
In 2014 he was awarded the "Louis Bachelier Prize" of the Natixis Foundation for Quantitative Research and the Société de Mathématiques Appliquées et Industrielles (SMAI) by the French Academy of Sciences.
In 2016 he received the "Bob Alting von Geusau Prize" sponsored by the AFIR-ERM Section of the International Actuarial Association (IAA) (together with Mario Wüthrich).

Since 2018 he is principal investigator of the SNF-Project "Mathematical Finance in the light of Machine Learning" (duration: 4 years, around CHF 1,000,000).

Invited lecture: Thu, 14:00-15:30 and Fri, 15:30-12:20, room A

Luitgard A. M. **Veraart** (London School of Economics)

**Systemic risk in financial networks**

The 2007-2008 financial crisis has highlighted the need for better risk management. In particular one needs to understand the interconnections in financial markets that can give rise to amplification and feedback effects. In this short course we show how network models can be used to model systemic risk in financial systems. We will look at different channels of systemic risk and mechanisms that can trigger default cascades/domino effects in financial systems. We show how network models can be used in macro-prudential stress tests to assess the stability of financial systems. We will also look at the problem of conducting such stress tests in situations where the financial system is not fully observable. We will conclude with some discussion on policy measures and new developments to enhance financial stability.

**Short Bio of Luitgard A. M. Veraart:**

Luitgard A. M. Veraart is Associate Professor at the Department of Mathematics of the London School of Economics and Political Science (LSE).

Her research interests focus on financial mathematics, particularly risk management in financial markets, financial networks, systemic risk, statistics in finance, optimal investment problems, modelling of energy markets and stochastic volatility models.

In 2019 she was co-winner of the Adams Prize awarded by the University of Cambridge, for achievements in the field of the Mathematics of Networks.
In 2016 received the award of a George Fellowship by the Houblon-Norman Fund, Bank of England, for her research on systemic risk in financial networks