# Lévy Processes and Applications

# Master Programme in Mathematical Finance

# 2017/2018

1 - Introduction
1.1.    Main concepts
1.2.    Main applications
1.3.    Brief history

2 – The imperfections of the Black-Scholes model
2.1. The empirical distribution of returns
2.2. The implied volatility

3 – Lévy processes: definiton, basic properties and examples
3.1. Infinitely divisible distributions
3.2. The Lévy measure
3.3. The Lévy-Khintchine formula
3.4. Stable distributions
3.5. Lévy processes - definition
3.6. Lévy processes – basic properties
3.7. Stable processes
3.8. Subordinators

4 – Stochastic calculus for Lévy processes
4.1. Poisson random measures
4.2. Poisson integrals
4.3. The Lévy-Itô decomposition
4.4. Stochastic integrals with respect to semimartingales
4.5. Stochastic integrals of Lévy-type
4.6. Itô formula for Poisson integrals and Lévy-type integrals
4.7. Stochastic exponentials
4.8. Exponential martingales
4.9. Martingale representation Theorems

5 – Lévy processes in mathematical finance
5.1. Change of measures and Girsanov Theorem
5.2. Lévy processes in asset pricing models
5.3. Incomplete markets, equivalent martingale measures and the Esscher transform
5.4. Some Lévy processes: Variance Gamma, NIG, hyperbolic and the CGMY process.

6. Option pricing with Lévy models
6.1. Option pricing with Lévy models: basic ideas
6.2. Option pricing using the Fourier Transform
6.3. Parameter estimation and exotic option pricing
6.4. Numerical simulation techniques

6.5. Integro-differential equations for option pricing
6.6. Lévy models with stochastic volatility

## Main Bibliography

_Applebaum, D. (2009), Lévy Processes and Stochastic Calculus, 2nd. Edition, Cambridge University Press.

_Cont, R. and Tankov, P. (2003), Financial modelling with Jump Processes, Chapman & Hall / CRC Press.

_Guerra, J. (2012), Lecture Notes - Lévy Processes and Applications, Texto didático, ISEG.

## Secondary bibliography

_Oksendal, B. and Sulem, A. (2007), Applied Stochastic Control of Jump Diffusions, 2nd. Edition, Springer.

_Papapantoleon, A. (2008), An introduction to Lévy processes with applications in finance. Lecture notes, TU Vienna, 2008, http://arxiv.org/abs/0804.0482

_Sato, K.-I. (1999), Lévy Processes and Infinitely Divisible Distributions, Cambridge University Press.

_Schoutens, W (2003), Lévy Processes in Finance, John Wiley & Sons.

## Assessment

Group assignment  (50%) + Final exam (50%). Minimum grade point at final exam: 8.

At the final exam, the students can bring some notes (up to a maximum of 7 sheets A4 (14 pages)).