A smooth tour around rough models in finance
(From data to stochastics to machine learning)

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\textbf{Timetable:} 16 hrs. May 2020, Torre Archimede, IBC/50.

\textbf{Course requirements:} Probability and Stochastic Calculus

\textbf{Examination and grading:} oral examination on the topics covered during the course

\textbf{SSD:} MAT/06, SECS-S/06

\textbf{Aim:} Aim: the course aims at introducing the recent theory on rough volatility models, namely stochastic volatility models in finance driven by the fractional Brownian motion. This class of models will naturally arise by looking at market data and at the end of the course the PhD student will have full control of advanced tools in stochastic calculus which are crucial in modern finance.

\textbf{Course contents:}

A quick glance at time series in market data (Equities, Currencies, Commodities, Rates...) leaves no doubt that volatility is not deterministic over time, but stochastic. However, the classical Markovian setup, upon which a whole area of mathematical finance was built, was recently torn apart when Gatheral-Jaisson-Rosenbaum showed that the instantaneous volatility is not so well behaved and instead features memory and more erratic path behaviour. Rough volatility was born. This new paradigm does not come for free, though, and new tools and further analyses are needed in order to put forward the benefits of this new approach. The goal of this course is to explain how Rough Volatility naturally comes out of the data, and to study the new techniques required to use it as a tool for financial modelling. We shall endeavour to strike a balance between theoretical tools and practical examples, and between existing results and open problems. The contents shall span, with more or less emphasis on each topic, the following:

2. Constructing a model consistent between the historical and the pricing measure: joint calibration of SPX and VIX options.
3. Pricing options in rough volatility models: from Hybrid Monte Carlo to Deep learning

The first item is anchored in fairly classical Statistics and Probability, while the second deals with Stochastic analysis. The last item draws upon recent literature connecting Path-dependent PDEs, Backward SDEs and Deep Learning technology. Prior knowledge in all areas is not required, but good Probability/Stochastic analysis background is essential.