GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Fachbereich Physik
Institut für Theoretische Physik

CONDENSED MATTER THEORY SEMINAR

Subject: **From many-body physics to financial markets: sparse modeling for inverse problems**

Speaker: **Dr. Daniel Guterding (Deutsche Börse AG)**

Date & time: **Friday, December 2nd, 2022 at 3:15 p.m.**

Venue: **Room 01.114 and online:**

Zoom Link:
https://uni-frankfurt.zoom.us/j/96520912647?pwd=NWZneE5XQmlwZFJlUXJpcUhDNEtKQT09

Many-body calculations at finite temperature often employ the widely known Matsubara formalism. This can be either for efficiency reasons or because parts of the computational technique may only be formulated on the imaginary frequency axis. A prominent example for the latter is dynamical mean-field theory (DMFT) with continuous-time quantum Monte Carlo (CTQMC) impurity solvers. While these techniques offer many advantages, they require a numerical transformation from the Matsubara axis to observable quantities on the real frequency axis, the so-called analytic continuation, which is fundamentally ill-defined.

Various algorithms for performing this infamous transformation of numerical data to the real axis have been known for quite some time, such as the continued fraction, Maximum entropy or stochastic analytic continuation methods. These either violate causality or are numerically expensive.

Recently, the method of sparse modelling has been applied to the analytic continuation problem with remarkable success. [1] Sparse models can be generated by one of the simplest machine learning algorithms, widely known as the Lasso. I show how such a simple algorithm gives sufficient answers to a problem that has been considered essentially unsolvable by the physics community.

Surprisingly, the same approach also solves one of the fundamental problem of Mathematical Finance, namely the accurate valuation of plain-vanilla options. In particular, arbitrage-free interpolations of market-quoted option prices or implied volatilities are needed for the pricing of most options. For this purpose, various standard interpolation techniques have been modified to accommodate the no-arbitrage conditions required by quantitative finance.

Despite this problem being so important for the field, the available approaches are quite involved and largely not stable against the noisy inputs that are often encountered in practical applications. I use the sparse modeling method to construct a few-parameter model for the relation between option price and terminal density. [2] By employing the singular value decomposition, there is no need to explicitly choose expansion or regression basis functions, such as they are encountered in many other methods. Furthermore, I show that my method by construction delivers arbitrage-free models even for inputs containing noise or severe arbitrage.

[1] Otsuki et al., J. Phys. Soc. Japan 89, 012001 (2020)

[2] Guterding, arXiv:2205.10865