BGTS Doctoral Day 2020

October 2, 2020

Session 1: Theory, Modelling and Applications: The Omnipresence of PDEs in Theoretical Sciences

Julian Hölzermann - economics

Pricing (Nonlinear) Interest Rate Derivatives under Volatility Uncertainty

In this talk, we study the pricing of nonlinear interest rate derivatives in the presence of volatility uncertainty. For this purpose, we consider an arbitrage-free bond market with volatility uncertainty. The volatility is uncertain in the sense of Knightian uncertainty, which is represented by a set of beliefs. Such a set of beliefs naturally leads to a sublinear expectation and a G-Brownian motion. The distribution of a G-Brownian motion is characterized by a nonlinear heat equation. As a consequence, we need to solve nonlinear partial differential equations in order to price interest rate derivatives. The nonlinearity of the model bears several issues compared to the classical linear case. Nevertheless, we are able to price all common interest rate derivatives.

Ismail Soudi - physics

Teleparallel gravity: the forgotten theory of gravity

In an unsuccessful attempt to unify electromagnetism with general relativity (GR), Einstein introduced teleparallel theories of gravity. Lately, a lot of interest has grown to use teleparallel gravity as an alternative theory of gravity in order to answer the dark matter problem. During this talk, I will introduce teleparallel gravity and explain its correspondence to GR.

Akansha Sanwal - mathematics

Nonlinear Schroedinger equation: local theory

We discuss local well-posedness for the nonlinear Schrödinger equation (NLS) with power type nonlinearity. We begin with the properties exhibited by the NLS and define the notion of a solution. Later, we answer the question about the existence of solutions to the equation when the initial datum lies in a low regularity space. We conclude by showing that the NLS on the real line is locally well-posed in L^2.

Session 2: Theoretical Prediction

Guido Nicotra - physics

The Higgs boson from theory to experiments

In building the current Standard Model of particles, physicists have encountered various difficulties. One of these was the irreconcilability between some fundamental symmetries and the mass of particles. The Higgs model was born in the 1960s to provide an unconventional explanation of how particles acquire their mass. In this talk, we will try to understand the main problems and the proposed solution, as well as some of the fundamental steps that led to the discovery of this last, fundamental puzzle piece.

Lennart Oelschläger - economics, mathematics

Detecting bearish and bullish markets in financial time series using hierarchical hidden Markov models

Financial markets exhibit alternating periods of rising and falling prices. Stock traders seeking to make profitable investment decisions have to account for those trends, where the goal is to accurately predict switches from bullish towards bearish markets and vice versa. Popular tools for modeling financial time series are hidden Markov models, where a latent state process is used to explicitly model switches among different market regimes. In their basic form, however, hidden Markov models are not capable of capturing both short- and long-term trends, which can lead to a misinterpretation of short-term price fluctuations as changes in the long-term trend. We discuss how hierarchical hidden Markov models can be used to draw a comprehensive picture of financial markets, which can contribute to the development of more sophisticated trading strategies.

Session 3: Mean-field games and interacting particle systems

Marco Rehmeier - mathematics

From interacting particle systems to nonlinear Fokker-Planck equations: An overview and recent uniqueness results

In the first part of the talk, we review the probabilistic model of N interacting particles driven by independent Brownian motions and the corresponding nonlinear Fokker-Planck equation as the resulting equation for the weak limit $N \to \infty$. Secondly, recent uniqueness results for such Fokker-Planck equations are presented, including an open problem, which is currently work in progress.

Jodi Dianetti - economics

Submodular Mean Field Games: Existence and Approximation of Solutions

Mean field games are limit models for non-cooperative symmetric N-player games with mean field interaction as the number of players N tends to infinity. In this talk, we introduce a class of mean field games with costs that are submodular with respect to a suitable order relation on the state and measure space. The submodularity assumption has a number of interesting consequences. Firstly, it allows us to prove existence of solutions via an application of Tarski's fixed point theorem, covering cases with discontinuous dependence on the measure variable. Secondly, it ensures that the set of solutions enjoys a lattice structure: in particular, there exist a minimal and a maximal solution. Finally, it guarantees that those two solutions can be obtained through a simple learning procedure based on the iterations of the best-response-map. This talk is based on a joint work with Giorgio Ferrari, Markus Fischer and Max Nendel.

Marius Neumann - physics

The Ising model in mean-field theory

The Ising model has many applications within its universality class. We will present why it is of interest in high energy physics (i.e., Quantum Chromo Dynamics), compare Ising model lattice simulations to its mean-field approximation, and from there point out the limits of the theory.