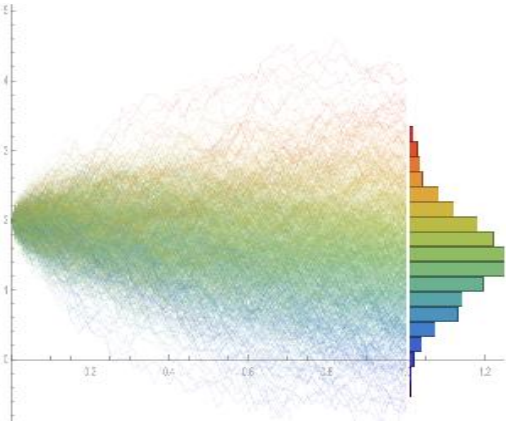
School of Mathematics



BSDEs, Information, McKean-Vlasov equations

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University of Leeds, 10 – 12 September 2018

Book of Abstracts

Organizing Committee: Katia Colaneri - University of Leeds
Elena Issoglio - University of Leeds

Sponsored by: ***London Mathematical Society*** and
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Programme

All talks will be in the MALL, which is located on Level 8 in the School of Mathematics at the University of Leeds

Monday 10 September		
9:00-10:00		**– Registration –**
10:00-10:45	**Saïd Hamadène**	Mean-field backward-forward stochastic differential equations and mean-field nonzero sum stochastic differential games
10:45-11:15	**Michele Coghi**	Mean field limit of interacting filaments for 3D Euler equations
11:15-11:45		**– Coffee Break –**
11:45-12:30	**Alexandre Popier**	A mean field game of optimal portfolio liquidation
12:30-13:00	**Vadim Kaushansky**	Simulation of particle systems interacting through hitting times
13:00-14:30		**– Lunch –**
14:30-15:15	**Gechun Liang**	Systems of infinite horizon and ergodic BSDEs arising in regime switching forward performance processes
15:15-15:45	**Giovanni Conforti**	The Schrödinger problem of weakly dependent particles
15:45-16:30		**–Coffee Break and Poster Session–**
16:30-17:15	**Francesco Russo**	Recent developments in stochastic calculus via regularizations with jumps and applications to BSDEs

Tuesday 11 September		
10:00-10:45	**Lukasz Szpruch**	Weak particle expansions of McKean-Vlasov SDEs
10:45-11:15	**Andreas Sojmark**	Dirichlet heat kernel type estimates for stochastic McKean–Vlasov equations with unbounded drift
11:15-11:45		**– Coffee Break –**
11:45-12:30	**Sam Cohen**	Uncertainty, Control and Filtering
12:30-13:00	**Tiziano De Angelis**	Optimal dividends with partial information and stopping of a degenerate reflecting diffusion
13:00-14:30		**– Lunch –**
14:30-15:15	**Marie Claire Quenez**	Non-linear pricing of European options in an incomplete market with default
15:15-16:00	**Miryana Grigorova**	Non-linear pricing of American options in an incomplete market with default
16:00-16:30		**–Coffee Break–**
16:30-17:15	**Claudia Ceci**	On optimal reinsurance and investment for partially observable insurance models: a BSDE approach
17:15-17:45	**Alessandro Calvia**	Optimal control of pure jump processes with noise free partial observation
17:45-18:30		**–Free time–**
18:30		**–Buffet Social Dinner–**

Wednesday 12 September		
10:00-10:45	**Huyên Pham**	Control of extended McKean-Vlasov systems
10:45-11:15	**Mario Maurelli**	A McKean-Vlasov SDE with reflecting boundaries
11:15-11:45		**– Coffee Break –**
11:45-12:30	**Dan Crisan**	Smoothing properties of McKean-Vlasov SDEs
12:30-13:00	**Stefano Pagliarani**	Fixed-point theorems and Picard iteration methods for a class of McKean-Vlasov SDEs with jumps
13:00		**– Closing remarks and Lunch –**

Abstracts

Talks

Alessandro Calvia, University of Milan – Bicocca

Optimal Control of pure jump Markov processes with noise-free partial observation

In this talk I am going to address an optimal control problem with partial information for a time-homogeneous pure jump Markov process, here denoted by $X = (X_t)_{t\geq 0}$. The aim is to minimize a discounted cost functional on infinite time horizon, by controlling the compensator of the signal process X via the information provided by the observed process $Y = (Y_t)_{t\geq 0}$. This information is of noise-free type, i.e., the observed process is not directly affected by randomness. At each time $t \geq 0$, the observation Y_t is given as a deterministic function of the signal X_t. More precisely, $Y_t = h(X_t)$, where $h : I \to O$ is a known measurable function, mapping the state space I of the signal process onto the state space O of the observed process. To avoid any triviality, we exclude the cases where h is constant or one-to-one. Finally, to achieve greater generality, I and O are assumed to be two complete and separable metric spaces. It is known that stochastic filtering is the first step to solve an optimal control problem with partial observation. The filtering process $\pi = (\pi_t)_{t\geq 0}$ provides, at each time $t \geq 0$, the conditional distribution of X_t given $Y_t = \sigma(Y_s : 0 \leq s \leq t)$, the available information up to time t. The peculiar structure of this problem allows to write down the SDE satisfied by the filtering process and, more importantly, to explicitly characterize it as a Piecewise Deterministic Markov Process. Once solved the filtering problem, the optimal control problem with partial observation is reformulated into a separated problem, that is a discrete-time optimal control problem for the filtering process with complete observation. I will show the equivalence between the original and the separated problems and prove a characterization of the value function of the latter one as the unique fixed point of a suitably defined contraction mapping. If time permits, I will briefly discuss the case of unobserved process given by a finite-state Markov chain (i.e. when the space I is of finite cardinality). In this case, more results can be obtained, namely: a characterization of the value function of the separated problem as the unique constrained viscosity solution (in the sense of Soner) of an integro-differential HJB equation; the existence of an optimal control, of piecewise open-loop type.

Claudia Ceci, University of Pescara

On optimal reinsurance and investment for partially observable insurance models: a BSDE approach

We study the optimal proportional reinsurance and investment problem for an insurer that has only partial information on intensity and claim size of the losses process. Precisely, we assume that the reserve process of the insurer is governed by a marked point process with dual predictable projection affected by an unobservable environmental stochastic factor described by a general Markov process. The insurer subscribes a reinsurance contract to reduce her/his risk exposure and, in addition, invests the surplus in an independent financial market consisting of a risk-free bond and a risky asset. We consider the criterion of maximizing the expected utility of the terminal wealth with exponential preferences. Using filtering results, we reduce the partially observable control problem to an equivalent problem with complete observations. By independence between the insurance and the financial markets we can separate the original optimization problem in two different control problems. We provide the optimal reinsurance strategy in terms of a BSDE driven by a marked point process and the optimal investment

strategy via a quadratic BSDE driven by a Brownian motion. We also discuss a model where the aggregate claims and the stock prices are correlated by means of a common shock, as it happens in presence of natural disasters or other detrimental incidents caused by human. In such a situation the insurance and financial markets are not anymore independent and the insurer has partial information on both the markets, since she/he does not know the intensity arrival of catastrophic events which influence insurance losses as well as stock prices. The talk is based on a joint work with Matteo Brachetta, PhD student at University of Chieti-Pescara, Italy.

[1] Brachetta, M. and Ceci, C. (2018) Optimal proportional reinsurance and investment for stochastic factor models, arXiv:1806.01223.
[2] Ceci C. (2012) Utility maximization with intermediate consumption under restricted information for jump market models, International Journal of Theoretical and Applied Finance, Volume 15, n. 6.
[3] Ceci C., and Colaneri K. (2012) Nonlinear filtering for jump diffusion observations, Advances in Applied Probability , Volume 44, n. 3, pp. 678–701.
[4] Confortola, F. and Fuhrman, M. (2013) Backward stochastic differential equations and optimal control of marked point processes. SIAM J. Control and Optimization, Volume 51, pp. 3592–3623.
[5] Confortola, F., Fuhrman, M., and Jacod, J. (2016) Backward stochastic differential equation driven by a marked point process: An elementary approach with an application to optimal control. The Annals of Applied Probability, Volume 26, n. 3, pp. 1743-1773.
[6] Grandell, J. (1991) Aspects of risk theory. Springer-Verlag.
[7] Liang, Z. and Bayraktar, E. (2014) Optimal reinsurance and investment with unobservable claim size and intensity. Insurance: Mathematics and Economics, Volume 55, pp. 156–166.
[8] Liang, Z., Yuen K.C., and Zhang C. (2017). Optimal reinsurance and investment in a jump-diffusion financial market with common shock dependence. J.Appl.Math.Comput.
[9] Lim, T. and Quenez, M.-C. (2011). Exponential utility maximization in an incomplete market with defaults. Electron. J. Probab., Volume 16, pp. 1434–1464.

Michele Coghi, WIAS Berlin

Mean field limit of interacting filaments for 3D Euler equations

Solutions to the 3D Euler equations are obtained as a mean field limit of finite families of interacting curves, the so called vortex filaments. Families of N interacting curves are considered, with long range, mean field type interaction. A family of curves defines a 1-current, concentrated on the curves, analog of the empirical measure of interacting point particles. This current is proved to converge, as N goes to infinity, to a solution of the 3D Euler equation. In the limit, each curve interacts with the mean field current and two different curves have an independence property if they are independent at time zero.

Sam Cohen, University of Oxford

Uncertainty, Control and Filtering Combining learning and decision making, or more formally filtering and optimal control, is a classical problem. In this talk, we will look at problems related to doing this in the presence of uncertainty, in a coherent manner.

Giovanni Conforti, Ecole Polytechnique

The Schrödinger problem for weakly dependent particles

An old problem studied by Schrödinger is that of determining the most likely evolution of a cloud of independent Brownian particles between two "unexpected" configurations: such question is

nowadays formulated as an Entropy minimization problem with marginal constraints. Drawing parallels with Optimal transport has led in the recent years to a much deeper understanding of it and allowed to establish some rather surprising connections with other active areas of research. In this talk, I will introduce a new version of the Schrödinger problem for weakly dependent particles and show its equivalence with both a Vlasov-Mc Kean control problem and with an optimal transport problem. Joint work with M.Beiglbock and Julio Backhoff.

Dan Crisan, Imperial College London

Smoothing properties of McKean-Vlasov SDEs

I will present integration by parts formulae on Wiener space for solutions of SDEs with general McKean-Vlasov interaction and uniformly elliptic coefficients. These integration by parts formulae hold both for derivatives with respect to a real variable and derivatives with respect to a measure understood in the sense of Lions. They allows us to prove the existence of a classical solution to a related PDE with irregular terminal condition. I will also present bounds for the derivatives of the density of the solutions of McKean-Vlasov SDEs. The talk is based on the paper:

[1] D. Crisan, E. McMurray (2018) Smoothing properties of McKean-Vlasov SDEs, Probability Theory and Related Fields, Volume 171, No 1-2, pp. 97–148.

Tiziano De Angelis, University of Leeds

Optimal dividends with partial information and stopping of a degenerate reflecting diffusion

Motivated by the optimal dividend problem, we study a problem of singular stochastic control with partial information on the drift of the underlying process and with absorption. In the Markovian formulation, we have a 2-dimensional degenerate diffusion, whose first component is singularly controlled and it is absorbed as it hits zero. The free boundary problem (FBP) associated to the value function of the control problem is challenging from the analytical point of view due to the interplay of degeneracy and absorption. We find a probabilistic way to show that the value function of the dividend problem is a smooth solution of the FBP and to construct an optimal dividend strategy. Our approach establishes a new link between multidimensional singular stochastic control problems with absorption and problems of optimal stopping with 'creation'. One key feature of the stopping problem is that creation occurs at a state-dependent rate of the 'local-time' of an auxiliary 2-dimensional reflecting diffusion.

Saïd Hamadène, Le Mans Université

Mean-field backward-forward stochastic differential equations and mean-field nonzero sum stochastic differential games

In this talk we discuss the problem of existence of a solution of a class of backward-forward stochastic differential equations of mean-field type. We show existence and uniqueness of a solution. As an application we discuss the problem of existence of an open-loop Nash equilibrium point for the mean-field nonzero-sum linear-quadratic stochastic differential game. Mainly, this problem turns into the resolution of a backward-forward stochastic differential equation considered in the first part for which we provide a solution. Joint work with Boualem Djehiche, KTH Stockholm, Sweden.

Miryana Grigorova, University of Leeds

Non-linear pricing of American options in an incomplete market with default

Vadim Kaushansky, University of Oxford

Simulation of particle systems interacting through hitting times

We develop an Euler-type particle method for the simulation of a McKean–Vlasov equation arising from a mean-field model with positive feedback from hitting a boundary. Under assumptions on the parameters which ensure differentiable solutions, we establish convergence of order 1/2 in the time step. Moreover, we give a modification of the scheme using Brownian bridges and local mesh refinement, which improves the order to 1. We confirm our theoretical results with numerical tests and empirically investigate cases with blow-up. This is a joint work with Prof. Christoph Reisinger.

Gechun Liang, University of Warwick

Systems of infinite horizon and ergodic BSDE arising in regime switching forward performance processes

We introduce and solve a new type of quadratic backward stochastic differential equation systems defined in an infinite time horizon. Such systems arise naturally as candidate solutions to characterize forward performance processes and their associated optimal trading strategies in a regime switching market. We also study the asymptotic limit of the infinite horizon BSDE system, which gives arise to a novel ergodic BSDE system. In addition, we develop a connection between the solution of the ergodic BSDE system and the long-term growth rate of classical utility maximization problems. Joint work with Ying Hu and Shanjian Tang.

Mario Maurelli, University of York

A McKean-Vlasov SDE with reflecting boundaries

In this talk, motivated by a model of lithium-ion batteries, we introduce a McKean-Vlasov SDE constrained on a bounded domain. The novelty lies in the particular interplay between the mean field interaction and the boundary conditions. We study well-posedness and particle approximation. Our analysis combines techniques for SDEs with Neumann boundary terms (Skorokhod equation, Lions-Sznitman) and ideas from a recent approach to McKean-Vlasov SDEs (Cass-Lyons). Joint work with Wolfgang Dreyer, Peter K. Friz, Paul Gajewski, Clemens Guhlke.

Huyên Pham, Université Paris Diderot

Control of extended McKean-Vlasov systems

This talk 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 problem is originally motivated from large population stochastic control in mean-field interaction, and 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. We present the dynamic programming approach for the control of extended McKean-Vlasov dynamics, including dependence on the law of the control, and 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. Some extensions and variations to the case of common noise, partial observation, and stochastic differential games are also discussed.

Stefano Pagliarani, University of Udine

Fixed-point theorems and Picard iteration methods for a class of McKean-Vlasov SDEs with jumps

We consider a class of Levy-driven SDEs with McKean-Vlasov (MK-V) interaction in the drift. The coefficient is assumed to be linear in the state-variable and only measurable in the law. We study the equivalent functional fixed-point equation for the unknown time-dependent coefficients of the associated Markovian SDE. By proving a contraction property for the functional map in a suitable normed space, we infer existence and uniqueness results for the MK-V SDE, and derive a discretized Picard iteration method that approximates the law of the solution. Numerical illustrations show the effectiveness of the method, which appears to be appropriate to handle multi-dimensional settings.

Alexandre Popier, Le Mans Université

A Mean Field Game of Optimal Portfolio Liquidation

We consider a mean field game (MFG) of optimal portfolio liquidation under asymmetric information. In the first part we recall the link between optimal liquidation and a (F)BSDE with singular terminal value, when there is only one player ([1, 2, 3]). Then we will explain how the solution to the MFG can be characterized in terms of a mean-field FBSDE with possibly singular terminal condition on the backward component or, equivalently, in terms of a mean-field FBSDE with finite terminal value, yet singular driver. Extending the method of continuation to linear-quadratic FBSDE with singular driver we prove that this FBSDE has a unique solution. This solution provides an optimal control for the MFG and we also obtain a ε-Nash equilibrium when the number of players is increasing. Finally our existence and uniqueness result allows to prove that the MFG with possibly singular terminal condition can be approximated by a sequence of MFGs with finite terminal values. Here contrary to the "classical" case and surprisingly, the penalized scheme does not directly give the solution of the initial FBSDE.

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Marie-Claire Quenez, Université Paris Diderot

Non-linear pricing of European options in an incomplete market with default

We first study pricing and hedging for European contingent claims in a complete imperfect market model with default, where the imperfections are taken into account via the nonlinearity of the wealth dynamics, expressed in terms of a nonlinear driver g. In this framework, the seller's

(resp. buyer's) pricing rule for European options corresponds to the nonlinear g-expectation $\mathcal{E}^g$, induced by a BSDE with default jump and driver g (resp. $-\mathcal{E}^g(-\cdot)$) We then consider the case when the imperfect market is incomplete. We study the *seller's price* of the European option, defined as the minimum of the initial capitals which allow her/him to build up a superhedging portfolio strategy. We provide a dual formulation of this price via a set of appropriate probability measures as well as an optional decomposition. In the case of linear wealth dynamics, these results correspond the ones shown in the literature. We also show that the seller's price process can be characterized as the minimal supersolution of a constrained non linear BSDE with default jump. This talk is based on joint works with M. Grigorova, A. Sulem and R. Dumitrescu.

Francesco Russo, ENSTA Paristech

Recent developments in stochastic calculus via regularizations with jumps and applications to BSDEs

The aim of this talk consists in mentioning recent developments about stochastic calculus via regularizations for jump processes. We recall that a *weak Dirichlet process* X with respect to a given underlying filtration is the sum of a local martingale and a process A such that $[A, N] = 0$ for every continuous local martingale. We introduce the notion of special weak Dirichlet process; whenever such a process is a semimartingale, then it is a special semimartingale. We will provide conditions on a function $u : [0, T] \times \mathbb{R}^d \to \mathbb{R}$ and on an adapted cadlag process S such that $u(t, S_t)$ is a special weak Dirichlet process. Two applications will be discussed.

1. The existence of a (strong) solution of a BSDEs with distributional driver, with underlying Brownian filtration (with Elena Issoglio, Leeds).

2. Consider the case a BSDE driven by a random measure: a solution is a triplet (Y, Z, K) where K is a random field. The function $u(s, x) := Y_s^{s,x}$ is deterministic. If u has some minimal regulartiy, the calculus will allow to link Z, K to u (with Elena Bandini, Milano Bicocca).

Andreas Sojmark, University of Oxford

Dirichlet heat kernel type estimates for stochastic McKean–Vlasov equations with unbounded drift

I will discuss a simple method for proving upper Dirichlet heat kernel type estimates for systems of interacting diffusions on the half-line –with absorption at the origin– when the drifts are unbounded (e.g. linear growth in space and in the empirical average) and have additional randomness (e.g. depending on the paths). Moreover, I will briefly outline how this can be applied to prove pathwise uniqueness for a general class of McKean-Vlasov type SPDEs on the half-line with Dirichlet boundary conditions.

Lukasz Szpruch, University of Edinburgh

Weak particle expansions of McKean-Vlasov SDEs

Posters

Andrew Allan, University of Oxford

Parameter Uncertainty in Stochastic Filtering

We propose an approach to construct stochastic filters which are robust with respect to model uncertainty, specifically, with respect to uncertainty in the parameters of the continuous time Kalman-Bucy filter. We use a nonlinear expectations approach, where our uncertainty is represented by a penalty function which may be propagated through time alongside the filter. We show how this penalty may be characterised as the value function of a pathwise stochastic optimal control problem, and may thus be computed by solving the associated HJB type PDE.

Cyril Benezet, Université Paris Diderot

Partial hedging: numerical methods

In this talk, we are going to introduce the problem of partial hedging. After recalling the stochastic problem modeling this problem and the PDE that the value function solves (in the viscosity sense), we present a numerical scheme to approximate the solution. This numerical scheme is based on Piecewise Constant Policy Timestepping (PCPT). This is a joint work with Jean-François Chassagneux and Christoph Reisinger.

Cheng Cai, University of Leeds

Optimal delta hedging for perpetual American put options

This project is dedicated to developing a threshold type delta hedging strategy using optimal stopping theorems. We take the perpetual American put option and keep the settings of Black-Scholes economy,but restrict that the option trader can only rebalance her hedging portfolio for a fixed N times. The goal is to determine the rebalance timing and the hedge ratios that minimize the variance of tracking error, when the underlying stock price hits the option exercise boundary a or a fixed upper boundary $b(\geq a)$. We first tackle the problem when N = 1, the calculation shows that optimal hedge ratio is adapted to the stock price, and it is not the Black-Scholes delta. After plugging this hedge ratio into the value function, the hedging problem becomes a one-dimensional optimal stopping problem. Using the method of [1], numerical plots of the payoff function indicate that the optimal stopping region is threshold type. This shows that there exist optimal thresholds, such that the option trader will only rebalance her portfolio if the stock price hits these thresholds. Justifying the result analytically is still in progress.

[1] S. Dayanik and I. Karatzas. (2003). On the optimal stopping problem for one-dimensional diffusions. Stochastic processes and their applications, Volume 107, n.2, pp. 173–212.

Bekzhan Kerimkulov, MIGSAA

Convergence rate in the value improvement algorithm

We are considering a specific stochastic control problem, where one needs to solve a nonlinear partial differential equation in order to get a value function. We use the value improvement algorithm to approximate *the nonlinear PDE with linear PDEs*, which solutions converge to the solution of the original PDE. We show this convergence using the theory of quadratic BSDE and obtain the convergence rate.

Nikita Merkulov, University of Leeds

An optimal stopping game with asymmetric information

We introduce a two-player game of optimal stopping with the following properties. A random switch in its structure - a change of the underlying diffusion parameters and of the interest rate - happens at a (possibly random) time. One of the players is informed about the result of this change in the beginning of the game. This information is revealed to another player only after the switch. We also consider separately the asymmetric information game before the switch (game A) and the full information game after the switch (game B). We re-formulate game A as a game of optimal control and optimal stopping. We discuss the conditions under which the initial game and the subgames A and B have a value and a Nash equilibrium.

Andreas Sojmark, University of Oxford

A McKean–Vlasov Problem with Blow-ups: Endogenous Contagion in Large Financial Systems

We propose a mean-field model for systemic risk in large financial systems, which we formulate as a system of interacting 'distance-to-default' processes on the positive half-line with absorption at zero corresponding to default. The idea is to build a structural framework, where simple notions of herding and common exposures can feed into an endogenous contagion mechanism which may lead to systemic default cascades.

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