ANTONIO OCELLO

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EMPLOYMENT

2023 – present **PostDoc in Statistics and Machine Learning** | Ecole Polytechnique (Palaiseau – France)

Funded by *ERC Synergy Grant "On intelligenCE And Networks" (OCEAN)*

Supervised by *Eric Moulines* (Professor, Ecole Polytechnique)

Topic: My research interests are *Mean-Field Games* (MFG) and *Mean-Field Control* (MFG) problems and their applications to Machine Learning (ML). My line of research is: looking for ML problems that can be rewritten as MFG-MFC problems to use probabilistic tools in the proof of convergence results and their rate; finding new learning algorithms for MFG-MFC with the help of Reinforcement Learning.

PREVIOUS EMPLOYMENT

2021 – 2023 **PhD in Probability** | LPSM - Sorbonne Université (Paris – France)

Funded by *École Doctorale de Sciences Mathématiques de Paris Centre 386*

Supervised by *Idris Kharroubi* (Professor, Sorbonne Université)

Topic: My research interests are *Stochastic control* and its interaction with other fields. I try to link different dynamics, like Branching processes or Superprocesses, to look for new PDE characterisations. Recently, I have started studying the probabilistic aspects of diffusion models, trying to explain their convergence theoretically and generalising these methods to wider fields.

EDUCATION

2019 – 2020 **Master 2 – Probability and Finance (ex-DEA *El Karoui*)** | École Polytechnique – Sorbonne Université (Paris – France)

Courses: Introduction to diffusion processes, Numerical probability for finance, Optimization and stochastic control, Machine learning, neural networks and deep learning, Risk measurements and extreme values theory, Stochastic processes and derivatives, High-frequency trading, Introduction to Jump Models, Evolution of Practices and Regulation, Valuation and Risk Management in Energy Markets, Stochastic Algorithms

Mention: *Bien*

2018 – 2019 **Master 1 – Mathematics and Applications** | Sorbonne Université (Paris – France)

Average: 18.47/20

2015 – 2018 **Bachelor's degree in Mathematics**| Università degli Studi di Padova (Padova – Italy)

Mark: 110/110 cum laude

2010 – 2015 **High School** (Italy)

Mark: 100/100 cum laude

PUBLICATIONS

2024 **A stochastic target problem for branching diffusion processes**, Idris Kharroubi, A.O.
Stochastic Processes and their Applications, Volume 170, 2024, arXiv:2206.13267

Abstract: We consider an optimal stochastic target problem for branching diffusion processes. This problem involves finding the minimal condition for which a control allows the underlying branching process to reach a target set at a finite terminal time for each branch. This problem is motivated by an example from fintech where we look for the super-replication price of options on blockchain-based cryptocurrencies. We first state a dynamic programming principle for the value function of the stochastic target problem. We then show that the value function can be reduced to a new function with a finite-dimensional argument by a so-called branching property. Under wide conditions, this last function is shown to be the unique viscosity solution to an HJB variational inequality.

ARTICLE DRAFTS

2024 **An analysis of the noise schedule for score-based generative models**, Stanislas Strasman, A. O., Claire Boyer, Sylvain Le Corff, Vincent Lemaire, arXiv:2402.04650

Abstract: Score-based generative models (SGMs) aim at estimating a target data distribution by learning score functions using only noise-perturbed samples from the target. Recent literature has focused extensively on assessing the error between the target and estimated distributions, gauging the generative quality through the Kullback-Leibler (KL) divergence and Wasserstein distances. All existing results have been obtained so far for time-homogeneous speed of the noise schedule. Under mild assumptions on the data distribution, we establish an upper bound for the KL divergence between the target and the estimated distributions, explicitly depending on any time-dependent noise schedule. Assuming that the score is Lipschitz continuous, we provide an improved error bound in Wasserstein distance, taking advantage of favourable underlying contraction mechanisms. We also propose an algorithm to automatically tune the noise schedule using the proposed upper bound. We illustrate empirically the performance of the noise schedule optimization in comparison to standard choices in the literature.

2024 **Optimal Stopping of Branching Diffusion Processes**, Idris Kharroubi, A.O., arXiv:2401.12811

Abstract: This article explores an optimal stopping problem for branching diffusion processes. It consists in looking for optimal stopping lines, a type of stopping time that maintains the branching structure of the processes under analysis. By using a dynamic programming approach, we characterize the value function for a multiplicative cost that depends on the particle's label. We reduce the problem's dimensionality by setting a branching property and defining the problem in a finite-dimensional context. Within this framework, we focus on the value function, establishing polynomial growth and local Lipschitz properties, together with an innovative dynamic programming principle. This outcome leads to an analytical characterization with the help of a nonlinear elliptic PDE. We conclude by showing that the value function serves as the unique viscosity solution for this PDE, generalizing the comparison principle to this setting.

2023 **Controlled superprocesses and HJB equation in the space of finite measures**, A.O., arXiv:2306.15962

Abstract: This paper gives the formalism to consider a class of stochastic control problems where the underlying controlled system is a super diffusion. We prove the existence of these processes as weak scaling limits of controlled branching processes. We derive a dynamic programming principle for our stochastic control problem by proving their uniqueness in law. This opens the way to a PDE characterisation for the associated value function, that relies on the notions of derivations in the space of finite positive measures. We conclude by proving that the value function is a solution to a Hamilton-Jacobi-Bellman PDE in the viscosity sense.

2023 **Relaxed formulation for the control of branching diffusions, Existence of an optimal control and Linear Quadratic problem**, A.O., arXiv:2304.07064

Abstract: We study the existence of optimal control for branching diffusion processes. We give a suitable relaxed formulation, showing a characterisation that relies on martingale measure. We introduce atomic control, proving them to be a copy of strong controls via their uniqueness in law and Doob's functional representation theorem. Under a Filippov-type convexity condition, we prove the equivalence between the strong and relaxed problem. Given the definition of the control rule, we re-read this problem as an optimisation of a continuous function over a compact set, proving the existence of optimal control. We then prove that the value functions satisfy a variational inequality. This helps us give a verification theorem, which we apply to an example of a Linear-Quadratic problem.

PROFESSIONAL ACTIVITIES

2020 ***Off-cycle internship*** | BNP Paribas Asset Management - Quant Research Group (Paris, France) *6 months*

- Development of multi-factor models on the credit market to generate positive alpha. Model selection, data analysis, and backtesting.

- Responding quickly to client queries. Cashflow simulations that take into account the risk of default and the risk of reinvestment. Construction of a client-serve infrastructure and of a GUI via dash.

2019 **Internship** | LPSM - Sorbonne Université (Paris – France) *3 months*

Applications of statistical models and extreme values theory to explain the magnitude of marine risks in collaboration with geologists

Supervised by: *Maud Thomas* (Assistant professor, Sorbonne Université)

2015 – 2017 **Barman** | "Al Vicolo", Castelfranco Veneto (TV), Italy

MINI-COURSE

July 2024 ***Mean field games for Machine Learning***, ERC OCEAN Summer retreat, University of Ca' Foscari, Venice, Italy

TEACHING EXPERIENCE

2023 – 2024 - *Random phenomena modeling: introduction to Markov chains and martingales* (Ingénieur 2A, Ecole Polytechnique, tutoring)

- *Numerical probability and computational statistics* (1st year, Master in Mathematics, Sorbonne Université, computer labs)
- *Mathematics* (Diplôme Universitaire de Retour aux Études Supérieures des Personnes Exilées - DU RESPE, Sorbonne Université)

2021 – 2022 - *Numerical probability and computational statistics* (1st year, Master in Mathematics, Sorbonne Université, computer labs)

- *Statistical modelling* (1st year, Master in Mathematics, Sorbonne Université, computer labs)
- *Stochastic calculus* (1st year, Master in Actuarial science, ISUP, exercise classes)

2021 – 2022 - *Numerical probability* (1st year, Master in Mathematics, Sorbonne Université, computer labs)

- *Stochastic calculus* (1st year, Master in Actuarial science, ISUP, exercise classes)

2017 – 2018 - *Affine, Euclidean, Hermitian and Projective Geometry* (1st year, Bachelor in Mathematics, Università degli Studi di Padova, exercice classes)

SCIENTIFIC ACTIVITIES

2022–ongoing **Co-organiser of *Les Probabilités de Demain*** | Paris, France

Les Probabilités de Demain *is a conference that aims to bring together probabilists from the Paris region. It is based on presentations by doctoral students from Île-de-France, with an introduction by a renowned researcher.*

2024–ongoing **Co-organiser of *Surfing the OCEAN*** | Paris, France

Surfing the OCEAN is the ERC synergy grant OCEAN monthly seminar aimed at fuelling collaboration and sharing fresh ideas about ongoing projects within the consortium.

2024–ongoing **Co-organiser of the *Seminar of the Statistics Unit* at CMAP, Ecole Polytechnique** | Palaiseau, France

PREVIOUS SCIENTIFIC ACTIVITIES

2021 – 2023 **PhD students representative** | École Doctorale de Sciences Mathématiques de Paris Centre 386, Paris, France

Representative of the doctoral students in all the École doctorale (ED) 386 *bodies (Council, etc…), bringing up requests or proposals and their criticisms about funding, training, scientific animation or ED policy. Member of the comity for the attribution of ED386 doctoral contracts to the following year's candidates. Mediator between the doctoral student and the ED to bring to the attention of the ED a complaint or a request related to the non-respect of the thesis charter.*

2021 – 2023 **PhD students representative** | LPSM - Sorbonne Université, Paris, France

Representative of PhD students in the Council of LPSM

2022 – 2023 **Co-organizer of InfoMaths** | Sorbonne Université, Paris, France

InfoMaths is a seminar about informatics tools for mathematicians

2021 – 2023 **Co-organiser of the PhD students seminar** | LPSM - Sorbonne Université, Paris, France

2016 – 2018 **Bachelor and Master students representative** | Università degli Studi di Padova, Padova, Italy

Link between students and faculty members, including participation in meetings with professors and researchers; member of Gruppo per l'accreditamento e la valutazione *(GAV), group for pedagogical evaluation in the Mathematics Department*

INVITED TALKS

September 2024 Workshop on **Risk management & Green finance**, Università degli Studi di Firenze, Florence, Italy
April 2024 **Young Researchers Seminar - CEREMADE**, Paris Dauphine University, Paris, France
March 2024 **Ph.D. students seminar**, LPSM - Sorbonne Université, Paris, France
March 2024 **Workshop of the SIMPAS group**, Puy-Saint-Vincent, France
March 2024 **Finance For Energy Market (FIME) PhD students' seminar**, Henri Poincaré Institute, Paris, France
February 2024 **Paris Bachelier Seminar**, Henri Poincaré Institute, Paris France
February 2024 **Séminaire Parisien de Statistique**, Henri Poincaré Institute, Paris France
November 2023 **Ph.D. Defense**, Sorbonne Université, Paris, France
November 2023 **Séminaire de probabilités et statistiques**, LAMA, Université Gustave Eiffel, Champs-sur-Marne, France
October 2023 **Chaire Modélisation Mathématique et Biodiversité**, Ecole Polytechnique, Palaiseau, France
September 2023 **Congrès des Jeunes Chercheurs en Mathématiques et Applications**, CentraleSupélec, Gif-sur-Yvette, France
March 2023 **Probabilistic methods in population biology**, TU Darmstadt, Darmstadt, Germany
December 2022 **Finance group seminar**, Pôle Universitaire Léonard de Vinci, Courbevoie - La Défense, France
November 2022 **Potsdam Research Seminar in Probability Theory**, Universität Potsdam, Potsdam, Germany
November 2022 **PhD students seminar of the LPSM**, LPSM - Sorbonne Université, Paris, France
September 2022 **London-Paris Bachelier Workshop**, Henri Poincaré Institute, Paris, France
June 2022 **Third Italian Meeting on Probability and Mathematical Statistics**, Università degli Studi di Bologna, Bologna, Italy
April 2022 **PhD students seminar of the LPSM**, LPSM - Sorbonne Université, Paris, France
April 2022 **Mathematical and statistical methods for Actuarial science and Finance (MAF2022)**, Università degli Studi di Salerno, Salerno, Italy

PRESENTED POSTERS

June 2024 **Fourth Italian Meeting on Probability and Mathematical Statistics**, University of Rome Tor Vergata, Sapienza University of Rome, the University of Roma Tre, and LUISS, Rome, Italy
March 2024 **French Japanese Conference on Probability & Interactions**, IHES - Marilyn and James Simons Conference Center, Bures-sur-Yvette, France
September 2023 **A Random Walk in the Land of Stochastic Analysis and Numerical Probability**, CIRM, Marseille, France
July 2023 **43rd Conference on Stochastic Processes and their Applications**, University of Lisbon, Lisbon, Portugal

ACADEMIC HONOURS

2018 - 2020 Fondation Sciences Mathématiques de Paris | **Scholarship PGSM for the Master's degree**
2017 - 2018 Università degli Studi di Padova | **Scholarship "Mille e una lode"**
Scholarship awarded to the top 3% of the University's best students

SKILLS

LANGUAGES Italian (*native speaker*) ; English (*level C1*) ; French (*level C1*) ; Spanish (*level C1*) ; Portuguese (*level A2*) ;
IT Python, R, LaTeX, Matlab, C++, Mathematica, HTML

ATTENDED CONFERENCES AND SCHOOLS

July 2024 **ERC OCEAN Summer retreat**, University of Ca' Foscari, Venice, Italy
June-July 2024 **Diffusions in machine learning: Foundations, generative models and non-convex optimisation**, The Alan Turing Institute, London, United Kingdom
May 2024 **A lifelong journey in stochastic analysis: from branching processes to statistical mechanics**, Institut Henri Poincaré, Paris, France
March 2024 **Journées Louis Antoine**, Université de Rennes, Rennes, France
March 2024 **Workshop on Particle Systems in Dynamics, Optimization, and Learning**, Lagrange Mathematics and Computation Research Center, Paris, France
January 2024 **Journées YSP (Young Statisticians and Probabilists)**, Institut Henri Poincaré, Paris, France
December 2023 **From matchings to markets. A tale of Mathematics, Economics and Computer Science**, CIRM, Marseille, France
December 2023 **NeurIps@Paris 2023, SCAI**, Paris, France
November 2023 **Les Probabilités de Demain**, Institut Henri Poincaré, Paris, France
September 2023 **Conférence en l'honneur d'Eric Moulines**, Institut Henri Poincaré, Paris, France
September 2023 **A Random Walk in the Land of Stochastic Analysis and Numerical Probability**, CIRM, Marseille, France
July 2023 43rd Conference on **Stochastic Processes and their Applications**, Lisbon, Portugal
May 2023 **Elisabeth Gassiat - a path in modern statistics**, Institut de mathématique d'Orsay, Orsay, France
March 2023 **Probabilistic methods in population biology**, TU Darmstadt, Darmstadt, Germany
January 2023 **Journées YSP (Young Statisticians and Probabilists)**, Henri Poincaré Institute, Paris, France
December 2022 **Les Probabilités de Demain**, Henri Poincaré Institute, Paris, France
December 2022 **Workshop on Mean Field Games and Applications**, Centre de recherche Lagrange en mathématiques et calculs, Paris, France
June 2022 **9th International Colloquium on BSDEs and Mean Field Systems**, Université Savoie Mont-Blanc, Annecy, France

June 2022	**Third Italian Meeting on Probability and Mathematical Statistics**, University di Bologna, Bologna, Italy
May 2022	**Stochastic Games and Martingale Optimal Transport**, Università degli Studi di Milano, Milano, Italy
May 2022	**Mathematical and statistical methods for Actuarial science and Finance (MAF2022)**, Università degli Studi di Salerno, Salerno, Italy
February 2022	**Journées YSP (Young Statisticians and Probabilists)**, Institut Henri Poincaré, Paris, France
February 2022	**Les Probabilités de Demain**, Institut Henri Poincaré, Paris, France
October 2021	**Workshop on *Mean-field reinforcement learning and applications***, King's College, London, UK
September 2021	**Les Probabilités de Demain**, Institut Henri Poincaré, Paris, France
May 2021	**Conference of Numerical Probability in honour of Gilles Pagès' 60th birthday**, Sorbonne Université, Paris, France
May 2019	**Conférence en l'honneur des 3×25 ans de Nicole El Karoui**, Sorbonne Université, Paris, France
June 2019	**Workshop on *Phase Transitions and Particle Systems***, Weierstrass Institute, Berlin, Germany