# MEAN FIELD INTERACTIONS WITH SINGULAR KERNELS AND THEIR APPROXIMATIONS CONFERENCE

BOOK OF ABSTRACTS

## Speakers

- Bertucci, Charles – École Polytechnique
- Butkovsky, Oleg – WIAS Berlin
- Coghi, Michele – University of Trento
- Dello Schiavo – Lorenzo, IST Austria
- Duboscq, Romain – INSA Toulouse
- Fournier, Nicolas – Sorbonne Université
- Frikha, Noufel – Université Paris 1
- Galeati, Lucio – EPF Lausanne
- Gassiat, Paul – Université de Dauphine
- Gess, Benjamin – Bielefeld University
- Guillin, Arnaud – Université Blaise-Pascal
- Zimo, Hao – Bielefeld University
- Issoglio, Elena – University of Turin
- Jabir, Jean-François – HSE University
- Jourdain, Benjamin – École des Ponts ParisTech
- Konarovskyi, Vitali – Hamburg University
- Le, Khoa – Leeds University
- Ling, Chengcheng – TU Wien
- Maurelli, Mario – University of Milan
- Mayorcas, Avi – University of Bath
- Ottobre Michela – Heriot Watt University
- Pham, Huyên – Université Paris Cité
- Richard, Alexandre – École Centrale Paris
- Ren, Zhenjie – Université Paris Dauphine
- Talay, Denis – INRIA Paris Saclay
- Tomasevic, Milica – École Polytechnique
- Touzi, Nizar – New York University
- Von Renesse, Max – Leipzig University
- Wagenhofer, Thomas – TU Berlin

## Poster Session

- Anzeletti, Lukas – TU Wien
- Béthencourt, Loïc – Université Côte d'Azur
- Fitoussi Mathis – Université Paris Saclay
- Petronilia, Aldair – Oxford University
- Salked, William – Brown University
- Songbo, Wang – École Polytechnique
- Suciu, Florin – Université Paris Dauphine

## Organizing committee

- Kebaier, Ahmed – University of Évry
- Menozzi, Stéphane – University of Évry
- Catellier, Rémi – Université Côte d'Azur
- Delarue, François – Université Côte d'Azur

| | 18/12/2023 | 19/12/2023 | 20/12/2023 | 21/12/2023 | 22/12/2023 |
|---|---|---|---|---|---|
| 09h00 - 09h45 | | Zima HAO<br>Second order fractional mean-field SDEs with singular kernels and measure initial data | Benjamin GESS<br>Large deviations from porous media and gradient flow structures | Arnaud GUILLIN<br>Propagation of chaos for some singular models | Huyên PHAM<br>Actor-Critic learning for mean-field control in continuous time |
| 09h45 - 10h30 | | Milica TOMASEVIC<br>Quantitative convergence of moderatly interacting particle systems towards some Fokker-Planck equations with singular drift | Michele COGHI<br>Malliavin Calculus for rough stochastic differential equations | Chengcheng LING<br>Path-by-path well-posedness and numerics of singular SDEs | Mario MAURELLI<br>Existence and uniqueness by Kraichnan noise for 2D Euler equations with unbounded vorticity |
| 10h30 - 11h00 | coffee break | coffee break | coffee break | coffee break | coffee break |
| 11h00 - 11h45 | Michela OTTOBRE<br>McKean-Vlasov S(P)Des with additive noise | Nizar TOUZI<br>Mean field control with common noise and viscosity characterisation on the lifted space. | Lucio GALEATI<br>A.e. uniqueness for (stochastic) Lagrangian trajectories for Leray solutions to 3D Navier-Stokes | Khoa LE<br>Sewing methods in differential equations | Vitalii KONAROVSKYI<br>Conservative SPDEs as fluctuating mean field limits of stochastic gradient descent |
| 11h45 - 12h30 | Zhenjie REN<br>Self-interacting approximation to McKean-Vlasov long time limit | Jean-François JABIR<br>Moderately interacting particle systems for singular kinetic McKean-Vlasov SDEs. | POSTER SESSION | Paul GASSIAT<br>Zero noise limit for singular ODE regularized by fractional noise | Nicolas FOURNIER<br>Particle systems for the Keller-Segel equation in the plane |
| 12h30 - 14h00 | lunch | lunch | lunch | lunch | lunch |
| 14h00 - 14h45 | WAGENHOFER, Thomas<br>On (local) rough stochastic volatility models and weak rates | Max VON RENESSE<br>A Central Limit Theorem for the Modified Massive Arratia Flow | Denis TALAY<br>Quantifying the weak convergence of fractional to Brownian diffuson first exit times | Benjamin JOURDAIN<br>Weak and strong error analysis for systems of particles with mean-field rank-based interaction in the drift | |
| 14h45 - 15h30 | Noufel FRIKHA<br>Well-posedness of McKean-Vlasov SDEs, related PDEs on the Wasserstein space and some new quantitative estimates for propagation of chaos. | Oleg BUTKOSKY<br>Stochastic Sewing, John-Nirenberg Inequality, and Taming Singularities for Regularization by Noise | Elena ISSOGLIO<br>McKean SDEs with singular coefficients | Alexandre RICHARD<br>Densities of SDEs driven by fractional Brownian motion, and application to McKean-Vlasov equations | |
| 15h30 - 16h00 | coffee break | coffee break | coffee break | coffee break | |
| 16h00 - 16h45 | Romain DUBOSCQ<br>Regularization by noise: a Malliavin calculus approach | Avi MAYORCAS<br>An additive noise approximation to the Keller-Segel-Dean-Kawasaki equation | Lorenzo DELLO SCHIAVO<br>The Dirichlet--Ferguson Diffusion on the space of probability measures over a closed Riemannian manifold | Charles BERTUCCI<br>A new look on dynamics of the spectrum of large random matrices | |
| Evening | | Conference diner | | | |

## Monday 18/12/2023

**11h00 - 11h45.** Ottobre, Michela (Heriot Watt University)

*Title.* McKean-Vlasov S(P)Des with additive noise

*Abstract.* Many systems in the applied sciences are made of a large number of particles. One is often not interested in the detailed behaviour of each particle but rather in the collective behaviour of the group. An established methodology in statistical mechanics and kinetic theory — This is a joint work with L. Angeli, D. Crisan, M. Kolodziejzik. allows one to study the limit as the number of particles N tends to infinity and to obtain a (low dimensional) PDE for the evolution of the density of particles. The limiting PDE is a non-linear equation, where the non-linearity has a specific structure and is called a McKean-Vlasov nonlinearity. Even if the particles evolve according to a stochastic differential equation, the limiting equation is deterministic, as long as the particles are subject to independent sources of noise. If the particles are subject to the same noise (common noise) then the limit is given by a Stochastic Partial Differential Equation (SPDE). In the latter case the limiting SPDE is substantially the McKean-Vlasov PDE + noise ; noise is further more multiplicative and has gradient structure. One may then ask the question about whether it is possible to obtain McKean-Vlasov SPDEs with additive noise from particle systems. We will explain how to address this question, by studying limits of weighted particle systems, in a framework introduced by Kurtz and collaborators.

**11h45 - 12h30.** Ren, Zhenjie (Université Paris Dauphine

*Title.* Self-interacting approximation to McKean-Vlasov long time limit

*Abstract.* Motivated by the mean-field optimization model of the training of two-layer neural networks, we propose a novel method to approximate the invariant measures of a class of McKean-Vlasov diffusions. We introduce a proxy process that substitutes the mean-field interaction with self-interaction through a weighted occupation measure of the particle's past. If the McKean-Vlasov diffusion is the gradient flow of a convex mean-field potential functional, we show that the self-interacting process exponentially converges towards its unique invariant measure close to that of the McKean-Vlasov diffusion. As an application, we show how to learn the optimal weights of a two-layer neural network by training a single neuron.

**14h00 - 14h45.** Wagenhofer, Thomas (TU Berlin)

*Title.* On (local) rough stochastic volatility models and weak rates

*Abstract.* The scope of this talk is two-fold : In part 1 we study the weak convergence of the Euler scheme of a rough stochastic volatility model driven by a fractional Brownian motion. We derive the optimal rate of convergence, depending on the Hurst parameter.

Part 2 is devoted to studying a local stochastic volatility model, described as a singular McKean—Vlasov equation. Given the open question of well-posedness of the original problem we show that one-dimensional marginals of the Euler scheme converge with weak rate 1. Finally, we propose some particle methods for simulation.

These are joint works with William Salkeld (part 1) and Peter Friz (part 1& 2)

**14h45 - 15h30.** Frikha, Noufel (Université Paris 1)

*Title.* Well-posedness of McKean-Vlasov SDEs, related PDEs on the Wasserstein space and some new quantitative estimates for propagation of chaos.

*Abstract.* In this presentation, I will discuss recent findings concerning the well-posedness of some non-linear stochastic differential equations (considering the McKean-Vlasov framework) in both weak and strong senses. These results go beyond what can be derived from the standard Cauchy-Lipschitz theory, as outlined in works such as Sznitman's monograph. Then, I will show how the underlying noise regularizes the equation and allows to prove that the transition density of the dynamics exists and is smooth, especially in the measure direction, under the uniform ellipticity assumption. Such smoothing effects then in turn allow to establish the existence and uniqueness for the Cauchy problem associated to the Kolmogorov PDE stated on the Wasserstein space with irregular terminal condition and source term. This PDE on an infinite dimensional space plays a key role in order to derive new quantitative estimates of propagation of chaos for the mean-field approximation by systems of interacting particles.

This presentation is based on two recent works in collaboration with P.-E. Chaudru de Raynal (Université de Nantes) :

- P.-E. Chaudru de Raynal, N. Frikha, Well-posedness for some non-linear SDEs and related PDE on the Wasserstein space, Journal de mathématiques pures et appliquées, 159 :1-167, 2022.
- P.-E. Chaudru de Raynal, N. Frikha, From the backward Kolmogorov PDE on the Wasserstein space to propagation of chaos for McKean-Vlasov SDEs, Journal de mathématiques pures et appliquées, 156 :1-124, 2021.

**16h00 - 16h45.** Duboscq, Romain (INSA Toulouse)

*Title.* Regularization by noise : a Malliavin calculus approach

*Abstract.* In this talk, we investigate the Cauchy problem of a rough differential equation (RDE) driven by a gaussian rough path and with a singular drift. This question is tackled by considering a type of mild formulation of the RDE through the flow associated to the equation without the drift. It turns out that we can prove a regularization by noise phenomenon thanks to this flow despite the fact that it implicitly depend on the noise. We will develop our idea which is based on to use Malliavin calculus, a martingale decomposition and some interpolations in Besov spaces.

This is a joint work with Rémi Catellier.

## Tuesday 19/12/2023

**9h00 - 9h45.** Hao, Zimo (Bielefeld University)

*Title.* Second order fractional mean-field SDEs with singular kernels and measure initial data

*Abstract.* In this talk we establish the local and global well-posedness of weak and strong solutions to second order fractional mean-field SDEs with singular/distribution interaction kernels and measure initial value, where the kernel can be Newton or Coulomb potential, Riesz potential, Biot-Savart law, etc. Moreover, we also show the stability, smoothness and the short time singularity and large time decay estimates of the distribution density. Our results reveal a phenomenon that for nonlinear mean-field equations, the regularity of the initial distribution could balance the singularity of the kernel. The precise relationship between the singularity of kernels and the regularity of initial values are calculated, which belongs to the subcritical regime in the scaling sense. In particular, our results provide a microscopic probabilistic explanation and establish a unified treatment for many physical models such as the fractional Vlasov-Poisson-Fokker-Planck system, the vorticity formulation of 2D-fractal Navier-Stokes equations, surface quasi-geostrophic models, fractional porous medium equation with viscosity, etc.

This is a joint work with Michael Röckner and Xicheng Zhang.

**9h45 - 10h30.** Tomasevic, Milica (École Polytechnique)

*Title.* Quantitative convergence of moderatly interacting particle systems towards some Fokker-Planck equations with singular drift

*Abstract.* In this talk we will study the convergence of moderately interacting particle systems with singular interaction kernels. We will prove quantitative convergence of the time marginals of the empirical measure of particle positions towards the solution of the limiting nonlinear Fokker-Planck equation. The results only require very weak regularity on the interaction kernel (local integrability) and the proofs are based on a semigroup approach combined with a fine analysis of the regularity of infinite-dimensional stochastic convolution integrals. We will also see how the method extends to non integrable kernels in the example of Burgers equation.

Based on joint works with C. Olivera (UniCAMP) and A. Richard (CentraleSupelec)

**11h00 - 11h45.** Touzi, Nizar (New York University)

*Title.* Mean field control with common noise and viscosity characterisation on the lifted space.

*Abstract.* Motivated by the problem of mean field control with common noise, we consider a general class of partial differential equations on the space of square integrable Ito processes, which appear naturally as the dynamic programming equation for a corresponding class of control problems. By introducing a suitable notion of viscosity solutions, we provide a comparison result between Lipschitz sub and supersolutions. The existence is obtained by a representation result which is standard for such dynamic programming equations.

**11h45 - 12h30.** Jabir, Jean-François (HSE University)

*Title.* Moderately interacting particle systems for singular kinetic McKean-Vlasov SDEs.

*Abstract.* This talk will address the propagation of chaos properties related to the particle approximation, with regularized interactions, for a class of singular Langevin-type McKean-Vlasov SDEs driven by a symmetric $\alpha$-stable Levy noise. The singularity of equation is represented by a (pairwise) interaction kernel belonging to a class of mixed Besov spaces with negative smoothness. Adapting the methodology recently introduced by Olivera, Richard and Tomašević (2021), we establish different weak and trajectorial propagation of chaos results in the regimes $\alpha = 2$ (Brownian noise) and $\alpha \in (1, 2)$ (pure-jump noise).

**14h00 - 14h45.** Von Renesse, Max (Leipzig University)

*Title.* A Central Limit Theorem for the Modified Massive Arratia Flow

*Abstract.* The Modified Massive Arratia Flow is a model of infinitely many sticky Brownian particles where the diffusion scaled proportionally to the aggregate mass of the particles. The model was introduced by Konarvovskyi and later studied by Konarovskyi and Renesse who showed that the diffusive behaviour of the model is governed locally by the quadratic Wasserstein distance. In this talk we present a central limit theorem for the occupation measure of the process in the case of countably many starting points. A central ingredient of the proof is quantitative decorrelation estimates in terms of the alpha-mixing coefficient for which we present explicit non-standard coupling constructions.

**14h45 - 15h30.** Butkovsky, Oleg (WIAS Berlin)

*Title.* Stochastic Sewing, John-Nirenberg Inequality, and Taming Singularities for Regularization by Noise

*Abstract.* The Stochastic Sewing Lemma (SSL) by Khoa Lê is a powerful tool for studying regularization by noise. However, when applied on its own, it might yield suboptimal results. On the other hand, a combination of SSL with other tools allows to achieve optimal results in various regularization by noise problems. I will illustrate this principle with the following examples : 1) the analysis of local times of an SDE/SPDE, 2) the rate of convergence of the Euler scheme for SDEs driven by Levy noise, and 3) the weak and strong well-posedness of SDEs with integrable drift.

**16h00 - 16h45.** Mayorcas, Avi (University of Bath)

*Title.* An Additive Noise Approximation to the Keller—Segel—Dean—Kawasaki Equation

*Abstract.* The Dean—Kawasaki (DK) equation is a proposed singular SPDE model for the random fluctuations of stochastic interacting particle systems around their mean field limits. However, it is by now well understood that the fully singular DK equation is ill-posed outside of a specific parameter set and that in this case the only solutions are empirical measures. This makes the continuum DK equation a challenge to study. In this talk I will present joint work with A. Martini (Oxford) in which we study an additive noise approximation to the DK equation for a stochastic particle model of chemotaxis. Applying the theory of paracontrolled distributions we obtain well-posedness of the approximate equation along with a generalised LLN, CLT and LDP.

**9h00 - 9h45.** Gess, Benjamin (Bielefeld University)

*Title.* Large deviations from porous media and gradient flow structures

*Abstract.* We consider the large deviations of the rescaled zero range process about its hydrodynamic limit. This leads to the analysis of the skeleton equation, a degenerate parabolic-hyperbolic PDE with irregular drift. In this talk, we present a robust well-posedness theory for such PDEs in energy-critical spaces based on concepts of renormalized solutions and the equation's kinetic form. The relation of such large deviations to a formal gradient flow interpretation of the porous medium equation will be drawn by deducing an entropy dissipation equality from the large deviations and reversibility.

**9h45 - 10h30.** Coghi, Michele (University of Trento)

*Title.* Malliavin Calculus for rough stochastic differential equations

*Abstract.* In this work we aim at developing a Malliavin Calculus for rough stochastic differential equations (RSDE) as they were introduced by Friz, Hocquet and Le.——As a first step we develop a comprehensive theory of linear rough stochastic differential equations, as this was not included in the original paper, where the coefficients are assumed to be bounded.——Under enough regularity on the coefficients, we prove Malliavin differentiability of the solution. When the diffusion coefficient satisfies appropriate, standard, ellipticity conditions, the solution admits a density with respect to the Lebesgue measure.——Finally, when the coefficients of the equation are smooth and satisfy an appropriate Hörmander condition, we prove that the solution is infinitely Malliavin differentiable and admits a smooth density with respect to the Lebesgue measure.

**11h00 - 11h45.** Galeati, Lucio (EPF Lausanne)

*Title.* A.e. uniqueness for (stochastic) Lagrangian trajectories for Leray solutions to 3D Navier-Stokes

*Abstract.* We revisit a result due to Robinson and Sadowski (2009), who first showed a.e. uniqueness of Lagrangian trajectories for admissible weak solutions to 3D Navier-Stokes, for sufficiently regular $u_0$. We give an alternative proof, based on a newly established asymmetric Lusin-Lipschitz property of Leray solutions, exploited crucially in the arguments from Caravenna-Crippa (2021) and Brué-Colombo-De Lellis (2021). This approach is more robust, requiring no assumptions on $u_0$ and being applicable also to the stochastic characteristics of the system. Finally, if $u_0$ is regular (say $u_0 \in H^{1/2}$), then we are able to exploit the diffusive behaviour of stochastic trajectories to further prove that, for any fixed $x_0 \in \mathbb{R}^d$, path-by-path uniqueness for the SDE $dX_t = u(t, X_t)dt + dB_t, X|t = 0 = x_0$.

**11h45 - 12h30.**

*Title.* POSTER SESSION

*Participants :*

- Anzeletti, Lukas (TU Wien)
- Béthencourt, Loïc (Université Côte d'Azur)
- De Scescenzo, Anna (Paris Sorbonne University)
- Fitoussi Mathis (Université Paris Saclay)
- Petronilia, Aldair (Oxford University)
- Salked, William (Brown University)
- Songbo, Wang (École Polytechnique)
- Suciu, Florin (Université Paris Dauphine)

**14h00 - 14h45.** Talay, Denis (INRIA Saclay Ile de France)

*Title.* Quantifying the weak convergence of fractional to Brownian diffuson first exit times

*Abstract.* In this lecture we shortly review convergence rate results which we had recently obtained on fractional diffusion first exit times when their Hurst parameter tends to the pure Brownian value. We then refine our analysis of the Laplace transform of these exit times when its variable takes small values. This refinement allows us to obtain accurate convergence rates for a suitable distance between the probability distributions of fractional first exit times and their corresponding Brownian limits.

The possible extension to mean-field diffusions will be discussed.

This is a joint work with Alexandre Richard (Centrale Supélec, France).

**14h45 - 15h30.** Issoglio, Elena (University of Turin)

*Title.* McKean SDEs with singular coefficients

*Abstract.* In this talk we consider a class of SDEs with drift depending on the law density of the solution, known as McKean SDEs. The novelty here is that the drift is singular in the sense that it is 'multiplied' by a generalised function (element of a negative Besov space). Those equations are interpreted in the sense of a suitable singular martingale problem, thus a key tool is the study of the corresponding singular Fokker-Planck equation. We define the notion of solution to the singular McKean equation using martingale problems, and show its existence and uniqueness. If time allows, an extension to kynetic-type McKean SDEs with singular coefficients will also be presented.

This talk is based on a joint work with F. Russo (ENSTA) and the last part on a joint work with S. Pagliarani (Bologna), D. Trevisani (A Coruna) F. Russo (ENSTA).

**16h00 - 16h45.** Dello Schiavo, Lorenzo (IST Austria)

*Title.* The Dirichlet–Ferguson Diffusion on the space of probability measures over a closed Riemannian manifold

*Abstract.* We construct a diffusion process on the $L^2$-Wasserstein space $P_2(M)$ over a closed Riemannian manifold $M$. The process, which may be regarded as a candidate for the Brownian motion on $P_2(M)$, is associated with the Dirichlet form induced by the $L^2$-Wasserstein gradient and by the Dirichlet–Ferguson random measure with intensity the Riemannian volume measure on $M$. We discuss the closability of the form via an integration-by-parts formula, which allows explicit computations for the generator and a specification of the process via a measure-valued martingale problem. If time allows, we shall comment how the construction is related to previous work of von Renesse–Sturm on the Wasserstein Diffusion, of Kondratiev–Lytvynov–Vershik on diffusions on the cone of Radon measures, and of Konarovskyi–von Renesse on the Modified Massive Arratia Flow.

Ann. Probab. 50(2) :591–648, 2022

## Thursday 12/12/2023

**9h00 - 9h45.** Guillin, Arnaud (Université Clermont Auvergne)

*Title.* Propagation of chaos for some singular models

*Abstract.* We will present quantitative propagation of chaos, uniform in time, for two different models. For the vortex 2D equation, in which the interaction Kernel is the Biot-Savart one, we complete the results of Fournier-Hauray-Mischler and Jabin-Wang, using entrpy methods linked to a new logarithmic Sobolev inequality of the non linear flow. For the 1D Dyson-Ornstein-Uhlenbck model, we use a coupling approach to get uniform in time Cauchy type propagation of chaos.

Joint work with Pierre Le Bris and Pierre Monmarché

**9h45 - 10h30.** Ling, Chenchen (TU Wien)

*Title.* Path-by-path well-posedness and numerics of singular SDEs

*Abstract.* Study on singular SDEs initiated by works of Zvonkin and Veretennikov from 70's, has been extensively explored among different concepts from stochastic calculus. In this talk we will introduce the ideas from classical Itô calculus involving the theory from PDEs and modern tools from rough path theory and Malliavin calculus for tackling the problems on path-by-path well-posedness theory and numerics.

This talk is based on the joint work with L. Anzeletti (TU Wien), Máté Gerencsér (TU Wien), Gerald Lampl (TU Wien) and L. Koha (Leeds University).

**11h00 - 11h45.** Le, Khoa (Leeds University)

*Title.* Sewing methods in differential equations

*Abstract.* The sewing lemma is originated from Lyons' rough path theory in 1998. Since then, the lemma had re-appeared in other occasions together with some improvements and new applications. The development can be seen through the works of Gubinelli 2004, Feyel - de La Pradelle 2006, Davie 2007 and through its recent stochastic extension. We will review the sewing lemmas via a unified perspective. Some recent applications to McKean-Vlasov equations and singular SDEs are discussed to illustrate the method.

**11h45 - 12h30.** Gassiat, Paul (Université Paris Dauphine)

*Title.* Zero noise limit for singular ODE regularized by fractional noise

*Abstract.* A classical manifestation of regularization by noise is that adding an irregular term to an ill-posed equation may restore well-posedness (existence/uniqueness). A natural question is then, in the limit where the coefficient in front of the noise is taken to zero, whether this selects one (or several) particular solutions to the original equation (this is typically referred to as "selection by noise"). In the case of one-dimensional ODEs, perturbed by a Brownian motion, Bafico and Baldi '82 showed that this procedure selects extremal solutions, i.e. those that exit the problematic point instantly. We extend this result to the case of fractional noise (and obtain in addition some exponential concentration estimates). The main difficulty lies in the absence of the Markov property for the system. Our proof is based on the dynamical approach of Delarue-Flandoli '14, combined with recent progress in regularisation by fractional noise (Catellier-Gubinelli '16), and techniques coming from the study of ergodicity of fractional SDEs (Hairer '05, Panloup-Richard '20).

Based on a joint work with Łukasz Mądry (Univ. Paris-Dauphine).

**14h00 - 14h45.** Jourdain, Benjamin (École des Ponts ParisTech)

*Title.* Weak and strong error analysis for systems of particles with mean-field rank-based interaction in the drift

*Abstract.* We first check trajectorial propagation of chaos with optimal rate of convergence given by the square root of the number $n$ of particles. We also prove that the empirical measure at time $t$ of the Euler discretization with step $h$ of the particle system converges to the corresponding marginal of the limiting McKean-Vlasov equation with strong rate $\mathcal{O}(\frac{1}{\sqrt{n}} + h)$ and weak rate $\mathcal{O}(\frac{1}{n} + h)$.

**14h45 - 15h30.** Richard, Alexandre (École Centrale Paris)

*Title.* Densities of SDEs driven by fractional Brownian motion, and application to McKean-Vlasov equations

*Abstract.* In this talk, we consider first the SDE $dX_t = b(t, X_t) + dB_t$, where $b$ is a distribution and $B$ is a fractional Brownian motion of Hurst parameter $H \leq 1/2$. We present and review recent well-posedness results about this equation, giving criteria that relate the regularity of $b$ and the parameter $H$. Then we study the time-space regularity of the density of the solution. Exploiting this regularity, we prove the existence of solutions for McKean-Vlasov equations of the form $dY_t = \mu_t * b(Y_t) + dB_t$, where $\mu_t$ is the law of the solution $Y_t$, for a drift $b$ which is allowed to be more singular than in the linear case.

Joint works with L. Anzeletti, L. Galeati and E. Tanré.

**16h00 - 16h45.** Bertucci, Charles (École Polytechnique)

*Title.* A new look on dynamics of the spectrum of large random matrices

*Abstract.* The dynamics of the spectrum of large (symmetric) random matrices often takes the form of system of SDE in singular interactions. In the mean field limit, we can characterize the dynamics of the spectrum through a PDE. It turns out that such a PDE can be studied using the theory of viscosity solutions. As usual in viscosity solutions, once a comparison principle is established, a great stability for the system can be obtained. I will revisit and extend some results of the literature through the lens of this observation, based on a joint work with M Debbah, JM Lasry and PL Lions.

**9h00 - 9h45.** Pham, Huyên (Université Paris Cité)

*Title.* Actor-Critic learning for mean-field control in continuous time

*Abstract.* We study policy gradient and actor-critic algorithm for solving mean-field control problems within a continuous time model-free a.k.a. reinforcement learning setting. The approach is based on a gradient-based representation of the value function, employing parametrized randomized policies. The learning for both the actor (policy) and critic (value function) is facilitated by a class of moment neural network functions on the Wasserstein space of probability measures, and the key feature is to sample directly trajectories of distributions. A central challenge addressed in this study pertains to the computational treatment of an operator specific to the mean-field framework. To illustrate the effectiveness of our methods, we provide a comprehensive set of numerical results. These encompass diverse examples, including multi-dimensional settings and nonlinear quadratic mean-field control problems with controlled volatility.

**9h45 - 10h30.** Maurelli, Mario (University of Milan)

*Title.* Existence and uniqueness by Kraichnan noise for 2D Euler equations with unbounded vorticity

*Abstract.* We consider the 2D Euler equations on $\mathbb{R}^2$ in vorticity form, with unbounded initial vorticity, perturbed by a suitable non-smooth Kraichnan transport noise, with regularity index $\alpha \in (0,1)$. This equation can be read as a mean field equation with common, non-smooth noise.

We show weak existence for every $\dot{H}^{-1}$ initial vorticity. Thanks to the noise, the solutions that we construct are limits in law of a regularized stochastic Euler equation and enjoy an additional $L^2([0,T];H^{-\alpha})$ regularity.

For every $p > 3/2$ and for certain regularity indices $\alpha \in (0,1/2)$ of the Kraichnan noise, we show also pathwise uniqueness for every $L^p$ initial vorticity. This result is not known without noise.

Joint work with Michele Coghi.

**11h00 - 11h45.** Konarovskyi, Vitalii (Hamburg University)

*Title.* Conservative SPDEs as fluctuating mean field limits of stochastic gradient descent

*Abstract.* My talk will be devoted to the convergence of stochastic interacting particle systems in the mean-field limit to solutions of conservative SPDEs. We will discuss the optimal convergence rate and derive a quantitative central limit theorem for such SPDEs. The results can be applied, in particular, to the convergence in the mean-field scaling of stochastic gradient descent dynamics in overparametrized neural networks. We will see that including the noise in the limiting equation improves the convergence rate and retains information about the fluctuations of stochastic gradient descent in the continuum limit. - The talk is based on joint work with Benjamin Gess and Rishabh S. Gvalani.

**11h45 - 12h30.** Fournier, Nicolas, (Sorbonne Université)

*Title.* Particle systems for the Keller-Segel equation in the plane

*Abstract.* The Keller-Segel equation describes the movement of cells by chemotaxis. Cells diffuse in the plane, and emit a chemical product. This product, which also diffuses, attracts cells. This leads to a relatively singular interaction between cells (via the product). This interaction is critical in the sense that, depending on the values of the constants, there can be global existence or explosion due to the formation of a cluster of cells in finite time. We will talk about the approximation of this equation by stochastic particle systems, in the elliptical case, where the product diffuses instantaneously, and in the parabolic case, where the product diffuses at a finite speed.

Issued from joint works with B. Jourdain, Y. Tardy and with M. Tomasevic.