EPFL

For Fundamental Studies
BERNOULLI CENTER

Celebrating Probability and Stochastics

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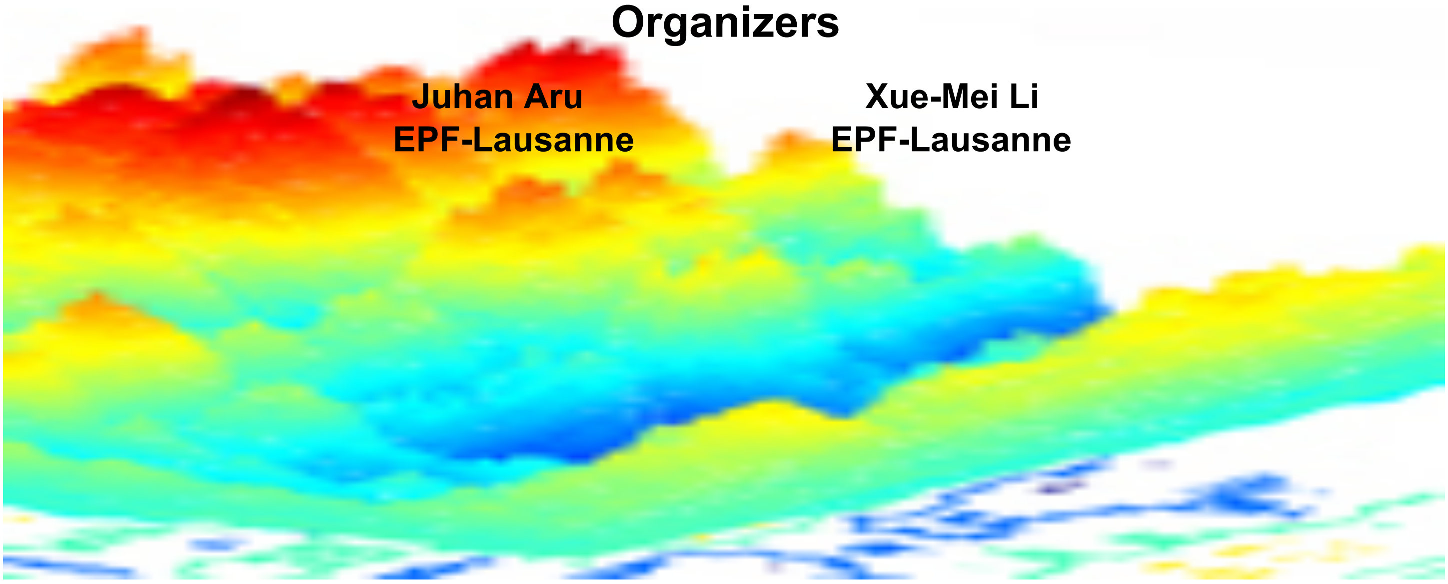
in honor of retiring Professors
Robert Dalang and Thomas Mountford

Titles and Abstracts



Organizers

Juhan Aru
EPF-Lausanne

Xue-Mei Li
EPF-Lausanne

Raluca Balan (**University of Ottawa**)

From Moment Bounds to Intermittency in Lévy-Driven SPDEs

In this talk, we introduce a new class of processes that can be used as noise for stochastic partial differential equations (SPDEs). This noise is called the "Lévy colored noise" and is constructed from a Lévy white noise using the convolution with a suitable spatial kernel. We assume that the Lévy measure of the noise has finite variance. The stochastic integral with respect to this noise is constructed similarly to the integral with respect to the spatially-homogeneous Gaussian case considered in Dalang (1999). Using Rosenthal's inequality, we provide an upper bound for the p-th moment of the stochastic integral with respect to this noise. Then we analyze the existence of moments for linear and non-linear SPDEs with this noise, considering as examples the stochastic heat and wave equations. This talk is based on joint work with Juan Jiménez.

Jiří Černý (**Universität Basel**)

Linear expansion speed for non-monotone particle systems

For interacting particle systems, monotonicity (that is the property that adding individuals to the initial condition stochastically increases the population at any later time) is a key ingredient in classical proofs of convergence to equilibrium and of linear expansion in time of the population in the survival regime. For non-monotone systems, there are mostly model specific arguments only.

In the talk, I will describe new comparison techniques which allow to adapt the classical arguments to population models which are non-monotone. Our prototypical example is a branching annihilating random walk. This talk is based on joint works with Matthias Birkner, Alice Callegaro, and Nina Gantert

Le Chen (**Auburn University**)

A class of d-dimensional directed polymers in a Gaussian environment

We introduce and analyze a broad class of continuous directed polymers in $\mathbb{R}^d$ driven by Gaussian environments that are white in time and spatially correlated, under Dalang's condition. Using an Itô-renormalized stochastic-heat-equation representation, we establish structural properties of the partition function, including positivity, stationarity, scaling, homogeneity, and a Chapman-Kolmogorov relation. On finite time intervals, we prove Brownian-type pathwise behavior, namely Hölder continuity and identification of the quadratic variation. We then obtain a sharp measure-theoretic dichotomy: the quenched polymer measure is singular with respect to Wiener measure if and only if $\hat{f}(\mathbb{R}^d) = \infty$ (equivalently, the noise is non-trace-class), and it is equivalent otherwise. Finally, in dimension $d \geq 3$, we prove diffusive behavior at large times in the high-temperature regime. This extends the Alberts-Khanin-Quastel framework from the 1+1 white-noise setting to higher-dimensional Gaussian environments with general spatial covariance.

This talk is based on joint work with Cheng Ouyang, Samy Tindel and Panqiu Xia

Sergey Foss (Heriot-Watt University)

Compressibility and Stochastic Stability of Monotone Markov Chains

For a stochastically monotone Markov chain taking values in a Polish space, we present a number of conditions for existence and for uniqueness of its stationary regime, as well as for closedness of its transient trajectories. In particular, we generalize a basic result by Bhattacharya and Majumdar (2007) where a certain form of mixing, or swap condition, was assumed uniformly over the state space. We do not rely on continuity properties of transition probabilities.This is a joint work with Michael Scheutzow.

Martin Hairer (École Polytechnique Fédérale de Lausanne EPFL)

TBA

TBA

Davar Khoshnevisan (University of Utah)

TBA

TBA

Annie Millet (Université Paris 1)

On the stochastic Non Linear Schrödinger equation for H^1-critical nonlinearities

We study random additive/multiplicative perturbations of the Non Linear Schrödinger equation in the case of H^1-critical nonlinearities in dimensions 3 to 5. We prove local well-posedness in the focusing/defocusing cases. In the focusing case, under proper assumptions on the initial condition, we give either quantitative results about the maximal existence time, or prove that blow-up occurs with positive probability. This is joint work with S. Roudenko.

Jean-Christophe Mourrat (**ENS Lyon and CNRS**)

Spin glasses and the Parisi formula

Spin glasses are models of statistical mechanics in which a large number of elementary units interact in a disordered manner. One of the main results of the theory is the Parisi formula, which describes the limit of the free energy of these systems. In this talk, I will describe a reformulation of this formula, as part of an effort to generalize the Parisi formula to models that still resist rigorous analysis.

Carl Mueller (**University of Rochester**)

The behavior of polyelectrolytes in three dimensions

There is a large literature in both mathematics and physics dealing with the path properties of self-avoiding or self-repelling walks on the integer lattice $\mathbb{Z}^d$. Typically one considers walks with with n steps, and studies the asymptotics of either the number of walks or the end-to-end distance of the walk. These questions give rise to well known unsolved problems in two and three dimensions.

In the self-repelling case, the repelling potential is usually local. A polyelectrolyte is a random walk with repelling potential c/r^{d-2}, which is considered as a long-range potential. In his seminal book, de Gennes asserted that in three dimensions, polyelectrolytes are fully extended. That is, they resemble a straight line. This assertion was based on physical reasoning. We give a mathematical proof of this result, at least up to logarithmic correction factors. This is joint work with Shiquan (Sophus) Li.

Eulalia Nualart (**Universitat Pompeu Fabra**)

Convergence of continuous-time stochastic gradient descent

We study the convergence of a continuous-time approximation of the stochastic gradient descent process for minimizing the population expected loss in learning problems. We show how our main result can be applied to the case of overparametrized neural network training. This talk is based on a joint work with Gabor Lugosi (Universitat Pompeu Fabra).

Fei Pu (**University of Utah**)

Spatial decorrelation in the KPZ equation started from a narrow wedge

In this talk, I will present the spatial decorrelation of the solution to the KPZ equation with narrow wedge initial data. For fixed $t > 0$, we determine the decay rate of the spatial covariance function, showing that $\mathrm{Cov}[h(t,x), h(t,0)] \sim \frac{t}{x}$ as $x \to \infty$. In addition, we prove that the finite-dimensional distributions of the properly rescaled spatial average of the height function converge to those of a Brownian motion. This is based on a joint work with Yu Gu.

Lluis Quer Sardanyons (**Universitat Autònoma de Barcelona**)

Weak and strong approximations for SPDEs

I will review some recent results on weak and strong convergence for the stochastic wave and heat equations. First, we consider these equations in $\mathbb{R}^d$, perturbed by an additive Gaussian noise that is white in time and has homogeneous spatial correlation with spectral measure μ_n. We provide sufficient conditions on μ_n and on the initial data to ensure that the corresponding solutions converge in law, in the space of continuous functions, to the solution of the equations driven by a noise with spectral measure μ, as $\mu_n \to \mu$ in an appropriate sense. We apply our main result to several types of noise, including anisotropic fractional noise.

Second, we study the stochastic heat equation on the interval $[0, 1]$, driven by space-time white noise. The diffusion coefficient is given by a nonlinear function satisfying suitable regularity assumptions. The equation is discretized in time using a stochastic exponential integrator, and we show that the corresponding weak error is of order $\frac{1}{2}$. The proof relies on techniques from Malliavin calculus. In particular, we establish appropriate pointwise estimates for the Malliavin derivatives of both the exact solution and the approximation.

Finally, I will present recent results on strong convergence for a stochastic heat equation on $[0, 1]^d$, driven by a Gaussian noise whose spatial correlation is given by a Riesz kernel. The approximation is constructed using an explicit exponential integrator. We prove strong error bounds and demonstrate how the convergence rate depends on the exponent in the Riesz kernel. Numerical experiments in spatial dimensions 1 and 2 are provided to confirm the theoretical convergence results.

This talk includes joint work with Charles-Edouard Bréhier, David Cohen, Maria Jolis, Salvador Ortiz, Samy Tindel and Johan Ulander.

Francesco Russo (**ENSTA Paris, Institut Polytechnique de Paris**)

About an entropic penalized optimation problem: drift correction of the solution in term of a generalized gradient

This talk will concern the exponential twist, i.e. a path-integral exponential change of measure, of a Markovian reference probability measure $\mathbb{P}$. This type of transformation naturally appears in variational representation formulae originating from the theory of large deviations and can be interpreted in some cases, as the solution of a specific stochastic control problem. Under a very general Markovian assumption on $\mathbb{P}$, we fully characterize the exponential twist probability measure as the solution of a martingale problem and prove that it inherits the Markov property of the reference measure. The "generator" of the martingale problem shows a drift depending on a *generalized gradient* of some suitable *value function* v. Applications of this work refer to an entropy minimization algorithm, see e.g. [1] and [3].

This work is based on a collaboration with Th. Bourdais (ENSTA and Mazars), and N. Oudjane (EDF). It is the object of [2].

References

[1] T. Bourdais, N. Oudjane, and F. Russo, An entropy penalized approach for stochastic control problem. *Complete Version.* Preprint HAL-04193113 v3, 2025.

[2] T. Bourdais, N. Oudjane, and F. Russo, Exponential twist of probability measures: drift correction in term of a generalized gradient. *Complete Version.* Preprint HAL-04644249 v2, 2025.

[3] T. Bourdais, N. Oudjane, and F. Russo, An entropy penalized approach for stochastic control problem. *SIAM Journal on Control and Optimization (SICON)*, 64(1):363–386, 2026.

Marta Sanz-Solé (**Universitat de Barcelon**)

Limit of random field solutions to stochastic heat equations over large intervals

We consider the nonlinear stochastic heat equation

$$(\partial_t - \partial_x^2)u_L(t,x) = b(t,x,u_L(t,x)) + \sigma(t,x,u_L(t,x))\,\dot{W}(t,x),$$

on $[0,T]\times[-L,L]$, driven by a space-time white noise W, with a given initial condition $u_0:\mathbb{R}\to\mathbb{R}$ and three different types of vanishing boundary conditions: Dirichlet, Mixed and Neumann. We show that as $L\to\infty$, the random field solution at any space-time position converges in the $L^p(\Omega)$-norm ($p\geq 1$) to the solution of the stochastic heat equation on $\mathbb{R}$ (with the same initial condition u_0), and we exhibit the rate of convergence.

This talk is based on a joint work with David Candil (EPFL) and Robert Dalang (EPFL).

Michael Unser (École polytechnique fédérale de Lausanne EPFL)

Variational Splines and Stochastic Processes: From Kernel Methods to ReLU Networks

The Wiener (MMSE) estimator of a Brownian motion (a.k.a. Wiener process) from noisy samples is a linear spline. Similarly, a variational reconstruction problem with second-order total variation regularization yields an adaptive linear spline solution. Deep neural nets with ReLU activations can also be interpreted as spline functions, albeit in higher-dimensional spaces. In this talk, I will show how these seemingly disparate results are unified through a common variational framework. I will further relate this perspective to stochastic modeling: kernel methods naturally correspond to Gaussian processes, while neural networks with a hidden ReLU layer are linked to a corresponding family of sparse stochastic processes.

References

[1] T. Blu, M. Unser, "Self-Similarity: Part II—Optimal Estimation of Fractal Processes," *IEEE Transactions on Signal Processing*, vol. 55, no. 4, pp. 1364–1378, April 2007.

[2] M. Unser, J. Fageot, J.P. Ward, "Splines Are Universal Solutions of Linear Inverse Problems with Generalized TV Regularization," *SIAM Review*, vol. 59, no. 4, pp. 769–793, 2017.

[3] M. Unser, "From Kernel Methods to Neural Networks: A Unifying Variational Formulation," *Foundations of Computational Mathematics*, vol. 24, pp. 1779–1818, 2024.

[4] R. Parhi, P. Bohra, A. El Biari, M. Pourya, M. Unser, "Random ReLU Neural Networks as Non-Gaussian Processes," *Journal of Machine Learning Research*, vol. 26, no. 19, pp. 1–31, 2025.

Daniel Valesin (University of Warwick)

The contact process on random bipartite graphs

The contact process is a model for the spread of an infection on a graph. In the last two decades, intensive research has been done on this process on classes of random graphs that capture aspects of real-world populations. A phenomenon of particular interest is that when the graph has vertices of high degree ("stars"), the infection stays active for a long time, even if the rate of spreading is very low. In 2011, Mountford, Valesin and Yao studied this phenomenon on random graphs where the degree distribution is a power law, and determined the exponents of the density of infection, which vary depending on the tail of the power law. These exponents reveal the best strategy for the infection to stay active on the graph, in a way that suggest universality among many classes of random graphs. This has been confirmed by subsequent works on other graphs, such as preferential attachment graphs, random hyperbolic graphs, and scale-free geometric random graphs. In ongoing work with John Fernley and Christian Hirsch, we consider the contact process on a random bipartite graph; hence, vertices are split between two types, both of which have power law degree distributions. We allow for distinct infection rates between the two types. This leads to a much richer phase diagram for the density exponents, and reveals further possible strategies for survival of the infection.