

Minicourse on
Statistical Mechanics and Singular SPDEs
Abstracts

18 May 2026–20 May 2026

May 15, 2026

Abstracts

Minicourse

Massive Scaling Limits in 2D Statistical Mechanics

Nathanael Berestycki

University of Vienna, Austria

Many models of statistical mechanics have a conformally invariant scaling limit when we consider them at their critical point; often this translates into geometric interfaces given by SLE curves, and associated random fields (height functions) which converge to the Gaussian free field.

It is however of great interest to understand these models when the parameter is close, but not exactly equal to its critical value. In this case we expect "massive scaling limits" which are no-longer conformally invariant, but are nonetheless nontrivial and have a rich, integrable structure.

In this mini-course, I will explain the idea of a massive SLE, which can in some cases be used to describe the scaling limit of the interfaces of some off-critical models. The study of the associated height functions is more challenging and we expect that in many models the scaling limit is a quantum field theory known as the sine-Gordon model. We will focus in particular on the near-critical dimer model; we will present an introduction to this circle of ideas and the tools needed to prove such results (such as Kasteleyn theory, the Coleman transform, and a theory of massive holomorphicity).

These results are based on joint works with Levi Haunschmid-Sibitz, and Scott Mason and Lucas Rey, respectively.

Low-temperature Expansion for the Magnetization of the 3D Classical Heisenberg Model

Alessandro Giuliani

Università Roma Tre, Italy

The classical Heisenberg model in three dimensions displays a low temperature phase with broken continuous rotational symmetry, a fact originally proved by Froehlich, Simon and Spencer via Reflection Positivity and Infrared Bounds. Spin wave theory provides a way to systematically, although formally, calculate the low temperature corrections to the spontaneous magnetization, beyond the naive, lowest-order, value computed via the Gaussian approximation. In this mini-course I will describe a rigorous proof of the asymptotic nature of such a low-temperature spin-wave expansion, which combines a priori bounds on the moments of the local spin observables, following from Reflection Positivity, with an integration-by-parts method applied systematically to a suitable integral representation of the correlation functions. The method of proof generalizes an approach, proposed originally by Bricmont and collaborators in 1981 in the context of the rotator model, to the case of non-abelian symmetry and non-gradient observables. Based on joint work with Sébastien Ott.

Sewing and Reconstruction, from Deterministic to Stochastic

Lorenzo Zambotti

Sorbonne Université, France

The recent activity in "pathwise" stochastic analysis is based on two main tools: sewing for SDEs and reconstruction for SPDEs. The first part of this mini-course is going to concern the deterministic statements and their first applications to evolution equations. In the second part I plan to discuss the stochastic versions of these results, or rather "some" stochastic versions. These probabilistic statements are much more recent and still in development.

Student Presentations

Wick Renormalized Parabolic Stochastic Quantization Equations on Rough Metric Measure Spaces

Hongyi Chen

Aarhus University, Denmark

On metric measure spaces with sub-Gaussian heat kernel behavior in small time, we obtain a sufficient condition to solve Wick renormalized stochastic quantization equations with polynomial interaction. Given the power of the nonlinearity, the local solution condition depends on the Hausdorff dimension d_w , the walk dimension d_w , and the maximal spatial Holder regularity of the heat kernel Θ . A slightly more restrictive condition based on the same parameters is required for a global solution. For all global solutions, we construct an invariant measure for the Markov process defined by the solution. Our results apply to many rough spaces such as Barlow–Kigami type fractals as well as their Cartesian products and open up the possibility of making rigorous various structures in quantum field theory and statistical mechanics in non-integer dimensions. In the process, we build entirely from the short-time heat semigroup the necessary analytic framework that accommodates the issues which come with allowing rough local geometry.

Noise Sensitivity and Directed Polymers

Anna Donadini

University of Milano-Bicocca, Italy

Noise sensitivity for functionals of independent random variables, introduced by Benjamini, Kalai and Schramm in 1999 in the context of Boolean functions, describes the phenomenon where a small perturbation of the underlying randomness leads to an asymptotically independent outcome. In this talk, we extend classical noise sensitivity criteria beyond the Boolean setting and derive quantitative estimates with optimal rates. We then consider the model of directed polymers in random environments, and apply our results to the regime in which the partition function converges to a universal limit known as the Stochastic Heat Flow, which we show to be independent of the white noise arising from the scaling limit of disorder.

Critical Last Passage Percolation

Victor Ginsburg

University of California, Berkeley, USA

Last passage percolation (LPP) is a model of random geometry where the main observable is a directed path evolving in a random environment. When the environment distribution has light tails and a fast decay of correlation, the random fluctuations of LPP are predicted to be explained by the Kardar–Parisi–Zhang (KPZ) universality theory. However, the KPZ theory is not expected to apply in many natural settings, such as "critical" environments exhibiting a hierarchical, fractal-like structure which should give rise to a fluctuation theory featuring logarithmic corrections with novel critical exponents. Predictions for these exponents are missing, even from the physics literature.

In recent joint work with Shirshendu Ganguly and Kyeongsik Nam we initiated the study of LPP in hierarchical environments, developing a framework based on multi-scale analysis and obtaining bounds on critical exponents for two canonical examples: an i.i.d. environment with critical power-law tails, and a hierarchical approximation of the two-dimensional Gaussian Free Field. I will describe these models and results. Time permitting, I will also touch upon ongoing work with Shirshendu Ganguly and Kaihao Jing exploring connections to fractal percolation as well as related polymer models.

Polynomial Chaos with Respect to a Lévy White Noise: Moments and Convergence

Gaspard Gomez

École Normale Supérieure, France

Polynomial chaos expansions provide a natural way to describe random variables measurable with respect to a white noise through (possibly infinite) sums of multiple stochastic integrals. While the Gaussian setting is by now well understood, much less is known when ζ is a non-Gaussian stable white noise. In this talk, I will present recent results on the moments of such polynomial chaoses, as well as sufficient conditions ensuring the convergence of discrete systems to a polynomial chaos limit.

A Statistical Analogue of Soliton Resolution for the Focusing Schrödinger Equation

Fabian Hofer

University of Münster, Germany

We study the infinite-volume limit of Gibbs measures for the one-dimensional focusing, mass-subcritical nonlinear Schrödinger equation. Under the critical scaling, we show that the measure concentrates around a single soliton over a Gaussian background.

This program was initiated by Lebowitz-Rose-Speer (1988), who introduced the grand-canonical ensemble for the focusing NLS and conjectured the existence of a phase transition in the infinite-volume limit. This conjecture was partially confirmed in recent work by Tolomeo-Weber (2026). Building on a soliton-Gaussian decomposition, we complete the analysis of the critical regime and show that, in this case, the measure exhibits a soliton resolution.

The talk is based on joint work with Justin Forlano (Monash University) and Leonardo Tolomeo (University of Edinburgh).

Weak Universality of KPZ with General Nonlinearity and Poisson Noise

Fanhao Kong

Peking University, China

We consider a class of weakly asymmetric continuous microscopic growth models with polynomial smoothing mechanisms, general nonlinearities and a Poisson type noise. We show that they converge to the KPZ equation after proper rescaling, where the coupling constant depends on all details of the smoothing and growth mechanisms in the microscopic model. This provides a first example of Hairer-Quastel type with both generic nonlinearity and non-Gaussian noise. This talk is based on the joint work with Haiyi Wang and Weijun Xu.

Moment Bounds of Partition Functions of Polymer Models and Asymptotic Independence of Pairwise Local Times

Ziyang Liu

University of Warwick, UK

I will discuss moment asymptotics for two-dimensional directed polymer partition functions in the subcritical regime, focusing on their connection with pairwise N -step collision local times of independent simple symmetric random walks. A previous work of Lygkonis and Zygouras shows asymptotic independence of pairwise local times through chaos expansion. In an ongoing work, we study how this behaviour changes when the number of particles is allowed to depend on N . Part of the required estimates relies on techniques developed in a work of Clément Cosco and Ofer Zeitouni.

An FBSDE for the Sine Gordon EQFT in Higher Regions

Sarah-Jean Meyer

University of Oxford, UK

I give a short introduction to a construction of the sine-Gordon EQFT up to 6π in the infinite volume and up to $6/7 \cdot 8\pi$ in the finite volume using a scale-by-scale coupling with the Gaussian free field using a forward backward stochastic differential equation (FBSDE).

On the Maximum of Gaussian Fields: from Loglog to Log Correlation

Zuodi Xie

University of Warwick, UK

We introduce a family of Gaussian fields whose covariance structure interpolates between a log log-correlated case with $\alpha = 1/2$ and a log-correlated case $\alpha = 0$. We prove the tightness for the recentered maxima of both the associated microscopically slowed-down branching Brownian motions and the corresponding Gaussian fields on R^d , and identify a phase transition at $\alpha = 1/3$.