HAUSDORFF RESEARCH INSTITUTE
FOR MATHEMATICS

UNIVERSITÄT BONN

"Gauge theories and spin systems: Yang-Mills theory, continuous symmetry, and disorder"

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organized by
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Abstracts

Malek Abdesselam (University of Virginia)

On correlation inequalities for non-Abelian spin systems and lattice gauge theories

Abstract: I will present a conjecture about inequalities for correlations of invariant observables in non-Abelian spin systems, and lattice gauge theories. These inequalities are expressed in terms of the non-interacting probability measure, but they would imply the analogue of the GKS inequality at non-zero coupling. A test of the conjectured inequalities is when integrands are taken to a large power. In that regime, one can prove the conjectured inequalities. This talk is partly about joint work with Gennady Uraltsev and Joe Webster.

Federico Camia (NYU Abu Dhabi)

On the logarithmic CFT structure of 2D critical percolation

Abstract: The large-scale behavior of two-dimensional critical percolation is expected to be described by a conformal field theory (CFT). Moreover, the latter is believed to be a log CFT, exhibiting logarithmic singularities together with the usual power-law divergences of CFT correlations functions. After a general introduction, I will discuss various (log) CFT features of the scaling limit of two-dimensional critical percolation, such as
- the recent proof of the conformal covariance of connection probabilities,
- its implications for the proof of the Delfino-Viti conjecture,
- asymptotic expansions that can be interpreted as operator product expansions (OPEs),
- the first rigorous proof of the emergence of logarithmic singularities,
- the percolation "energy" field and its logarithmic partner.

Sky Cao (MIT)

Expanded regimes of area law for lattice Yang-Mills theories

Abstract: I will discuss a recent result which extends the parameter regimes for which Wilson's area law is proven for pure U(N) lattice Yang– Mills theories, in particular when N is large. This improves

on a classical result of Osterwalder-Seiler from 1978. To do so, we view the master loop equation as a linear inhomogeneous equation for Wilson string expectations, and then prove an a priori bound for solutions to the equation. Joint work with Ron Nissim and Scott Sheffield.

Ilya Chevyrev (Edinburgh)

Observables and gauge covariant renormalisation of stochastic 3D Yang-Mills

Abstract: In this talk, I will describe a family of observables for 3D quantum Yang-Mills theory based on regularising connections with the YM heat flow. I will describe how these observables can be used to show that there is a unique renormalisation of the stochastic quantisation equation of YM in 3D that preserves gauge symmetries, which complements a recent result on the existence of such renormalisations. Our analysis is based on short time expansions of SPDEs and of regularised Wilson loops, and requires a careful balance between the running time of the dynamic and the regularisation parameter coming from the YM heat flow. Based on joint work with Hao Shen.

Paul Dario (CNRS / Université Pari-Est Créteil)

Delocalization for integer-valued height functions in the presence of a random disorder

Abstract: In this talk, we will discuss the properties of a model of random interfaces known as the integer-valued Gaussian free field. One of the fundamental features of this model is the existence of a localisation/delocalisation phase transition in two dimensions. From a mathematical perspective, this result was first established by FrÃ¶hlich and Spencer in 1981 and has recently been the subject of renewed activity following the works of Lammers, van Engelenburg and Lis, and Aizenman, Harel, Peled and Shapiro. We will present the model and some of its properties. We will then address the following question: does the phase transition persist when the integer-valued Gaussian free field is subject to a random disorder? Specifically, is it observed when the following random constraint is incorporated to the model: we sample a supercritical Bernoulli bond percolation on $\mathbb{Z}^2$ and, for each closed edge of the percolation configuration, we constrain the integer-valued Gaussian free field to take the same values on both ends of the edge? This is joint work with Diederik van Engelenburg and Christophe Garban.

Margherita Disertori (Universität Bonn)

An exact block-spin renormalization on the hierarchical non-linear supersymmetric hyperbolic sigma model

Abstract: Initially introduced as toy model for quantum diffusion, the non-linear supersymmetric hyperbolic sigma model has been attracting much attention in recent years due to its connection to history dependent stochastic processes. In this talk I will present a version of the model with hierarchical interactions. The internal symmetries of the model allow to perform some block-spin renormalization steps exactly. The resulting effective action has renormalized coefficients but no additional interaction terms. I will show the corresponding derivation and some applications.
This is joint work with S. Rolles and F. Merkl.

Ewain Gwynne (University of Chicago)

Liouville quantum gravity with central charge in $(1, 25)$

Abstract: I will give an overview of several recent results concerning Liouville quantum gravity in the supercritical (a.k.a. strongly coupled) phase, which corresponds to central charge $c \in (1, 25)$, or equivalently coupling constant $\gamma \in \mathbb{C}$ with $|\gamma| = 2$. Such results include the existence of a metric, the non-existence of an area measure, a coupling with CLE_4, and connections to random planar maps. Based on joint works with Morris Ang, Manan Bhatia, Jian Ding, and Jinwoo Sung.

Tyler Helmuth (University of Durham)

Continuous Symmetries and the Arboreal Gas

Abstract: I will begin by reviewing (some of) what is known and conjectured about $O(N)$ spin models. This is meant to motivate the study of the arboreal gas, a combinatorial probability model of random forests. Surprisingly, the arboreal gas has a hidden continuous symmetry similar to that of an $O(N)$ model. As a consequence one expects it to behave similarly. This turns out to be correct: several important rigorous results for $O(N)$ spin models have been shown to hold for the arboreal gas. The combinatorial nature of the arboreal gas suggests it may be a simpler setting than the $O(N)$ models for investigating open conjectures.

Piet Lammers (Sorbonne University / CNRS)

Towards GFF convergence for the six-vertex model

Abstract: ABSTRACT The six-vertex model is a height function model that serves as a unifying framework for several two-dimensional statistical mechanics systems. In this talk, I will present a proof of a long-standing conjecture asserting that the height function converges, in a certain parameter regime, to the Gaussian Free Field (GFF). The proof combines techniques from different areas of mathematics: at its core is a soft analysis of the transfer matrix, which notably avoids reliance on the Bethe Ansatz. This analysis is made rigorous through probabilistic tools, including the Fortuin-Kasteleyn-Ginibre (FKG) inequality and Russo-Seymour-Welsh (RSW) theory. This is joint work with Hugo Duminil-Copin, Karol Kozlowski, and Ioan Manolescu. I will also discuss a closely related conjecture—that the Fortuin-Kasteleyn percolation associated with the six-vertex model converges in the scaling limit to a Conformal Loop Ensemble,CLE(κ).

Marcin Lis (TU Wien)

The Ising magnetization field and the Gaussian free field

Abstract: I will define an (alternative to the FK-random cluster model) Edwards-Sokal representation of the Ising model using random currents. I will then discuss a scaling limit result which implies that the continuum Ising magnetization field and the Gaussian free field are naturally coupled. To the best of our knowledge, the existence of such a coupling was not predicted before. This extends the picture of bosonization of the planar Ising model. Based on joint work in progress with Tomas Alcalde and Lorca Heeney.

Florian Schweiger (University of Geneva)

Delocalization for the solid-on-solid model and variants

Abstract: Integer-valued effective interface models such as the solid-on-solid model arise, for example, when describing the interfaces between different phases in the Ising model. In two dimensions they are expected to have a BKT transition from localized to delocalized behavior as the temperature increases. The existence of a delocalized phase was first shown for various models by Fröhlich and Spencer in the eighties, and in the last few years elegant alternative approaches for special cases have been developed. In the talk I will survey these results, and then describe joint work with Sébastien Ott, where we adapt the method of Fröhlich-Spencer to some new settings.

Jinwoo Sung (University of Chicago)

Random walk reflected off of infinity

Abstract: Consider an infinite graph on which simple random walk is transient. I will discuss how to define a version of the random walk which is reflected upon reaching (possibly many) infinite ends of the graph. We then apply this process to study random planar maps in the universality class of supercritical Liouville quantum gravity (LQG), with central charge c in (1,25). Such random planar maps are infinite, with uncountably many ends. We define a version of the Tutte embedding for such maps under which they conjecturally converge to LQG, and introduce phase transition conjectures for free uniform spanning forest and critical percolation depending on the central charge of the model. This is joint work with Ewain Gwynne.

Rongchan Zhu (Beijing Institute of Technology)

Makeenko-Migdal equations for 2D Yang–Mills: from lattice to continuum

Abstract: In this talk, we consider the convergence of the discrete Makeenko–Migdal equations for Yang–Mills model on $(\varepsilon\mathbb{Z})^2$ to their continuum counterparts on the plane, in an appropriate sense. The key step in the proof is identifying the limits of the contributions from deformations as the area derivatives of the Wilson loop expectations. This talk is based on joint work with Hao Shen and Scott Smith.

Xiangchan Zhu (Chinese Academy of Sciences)

Φ_3^4 Theory from many-body quantum Gibbs states

Abstract: We derive the Φ_3^4 measure on the torus as a rigorous limit of the quantum Gibbs state of an interacting Bose gas, where the limiting classical measure describes the critical behavior of the Bose gas just above the Bose–Einstein phase transition. Since the quantum problem is typically formulated using a nonlocal interaction potential, a key challenge is to approximate the local Φ_3^4 theory by a Hartree measure with a nonlocal interaction. This requires uniform estimates on the Hartree measure, which are achieved using techniques from recent development on stochastic quantization and paracontrolled calculus from [**?**]. The connection to the quantum problem is then established by applying the variational approach in [**?**], where using a recent correlation inequality from [**?**] we refine the analysis and derive a quantitative convergence of the quantum correlation functions to those of the Hartree classical field.
