Spring school HU Berlin, 8-12 Mai 2023

3 facets of gravity

Rejzner/Schiavina

Effective BV quantisation of gravity

Rhodes/Vargas

Liouville quantum gravity & the conformal bootstrap

Ambjorn/Budd

Random geometry in the path integral approach to quantum gravity

Organisers Guillaume Baverez, Gaetan Borot

Some funding is available for young reseachers. For registration, info and application , see www.bgrav23.de

HUMBOLDT-UNIVERSITÄT ZU BERLIN

Timetable

Monday	
9 - 10:30	Rhodes-Vargas I
10:30 - 11	*Coffee break*
11 - 12:30	Rejzner-Schiavina I
12:30 - 14	*Lunch*
14 - 15:30	Ambjørn-Budd I
15:30 –	Poster session

Tuesday	
9 - 10:30	Rezjner-Schiavina II
10:30 - 11	*Coffee break*
11 - 12:30	Ambjørn-Budd II
12:30 - 14	*Lunch*
14 - 15:30	Rhodes-Vargas II
15:30 - 15:45	*Coffee break*
15:45 - 16:45	Rhodes-Vargas tutorial
17 - 17:30	Castro

Wednesday	
9 - 10:30	Rhodes-Vargas III
10:30 - 10:45	*Coffee break*
10:45 - 11:45	Ambjørn-Budd tutorial
12 - 12:30	Canepa
12:30 - 19:30	*Free afternoon*
19:30 –	*Conference dinner*

Thursday	
9 - 10:30	Rezjner-Schiavina III
10:30 - 11	*Coffee break*
11 - 12:30	Rhodes-Vargas IV
12:30 - 14	*Lunch*
14 - 15	Rezjner-Schiavina tutorial
15 - 15:15	*Coffee break*
15:15 - 16:45	Ambjørn-Budd III
17 - 17:30	Albenque

Friday	
9 - 10:30	Rezjner-Schiavina IV
10:30 - 10:45	*Coffee break*
10:45 - 11:45	Ambjørn-Budd IV

Abstracts of courses

Rémi Rhodes & Vincent Vargas

Aix-Marseille University & Université de Genève

Liouville quantum gravity and the conformal bootstrap

We present a rigorous probabilistic construction of Liouville Conformal Field Theory (LCFT). Then we explain how to derive the bootstrap formulae for this CFT via Segal's axioms, hence bridging the gap between probability theory and representation theory for LCFT. In particular, we explain how to identify its 3-point correlation functions (the celebrated DOZZ formula) and its spectrum. Finally, we explain how it serves to "glue" together the partition functions on Riemann surfaces with boundaries.

Katarzyna Rejzner & Michele Schiavina

York University & Università degli Studi di Pavia

Effective BV quantisation of Gravity with and without boundary

We will discuss recent developments in the effective quantisation of gravity, seen as a field theory on manifolds with and without boundary. We will introduce techniques from Perturbative Algebraic Quantum Field Theory as well as from the BV-BFV approach to Lagrangian field theories, and show how they can be related.

Jan Ambjørn & Timothy Budd

Niels Bohr Institute & Radboud University

Random geometry in the path integral approach to quantum gravity

This course will focus on the role of random geometry models in the search for a non-perturbative description of quantum gravity. We will highlight mathematical advances in the understanding of two-dimensional toy models of quantum gravity as well as explorations in higher-dimensional models, including (causal) dynamical triangulations.

Abstracts of talks

Marie Albenque

École polytechnique

Slice decomposition of hypermaps

Many bijections between maps and decorated trees have been developed in the last 20 years. In 2010, Jérémie Bouttier and Emmanuel Guitter introduced a new bijective paradigm for maps, called the "slice decomposition". It consists in cutting maps along some geodesic paths to produce some sort of canonical building blocks. This decomposition enables to obtain recursive decompositions, similar to the ones already available for decorated trees, but it also leads to new constructions and decompositions. In my talk, I will present the extension of the slice decomposition to hypermaps (i.e maps in which faces can be properly coloured in two colours), which permits to derive bijective proofs for enumerative formulas obtained in the physics literature. This is a joint work with Jérémie Bouttier.

Giovanni Canepa

Vienna Universität

Corner Structure of Four-Dimensional General Relativity in the Coframe Formalism

This talk describes a local Poisson structure (up to homotopy) associated to corners in four-dimensional gravity in the coframe (Palatini-Cartan) formalism. This is achieved through the use of the BFV formalism. This is a joint work with A. S. Cattaneo.

Alicia Castro

Radboud University

Scale-invariant random geometries from mating of trees

In this talk, I present new results on the search for scale-invariant random geometries in the context of Quantum Gravity. To uncover new universality classes of such geometries, we generalized the mating of trees approach, which encodes Liouville Quantum Gravity on the 2-sphere in terms of a correlated Brownian motion describing a pair of random trees. We extended this approacyouh to higher-dimensional correlated Brownian motions, leading to a family of non-planar random graphs that belong to new universality classes of scale-invariant random geometries. We developed a numerical method to efficiently simulate these random graphs and explore their scaling limits through distance measurements, allowing us to estimate Hausdorff dimensions in the two- and three-dimensional settings.

Posters

Hristu Culetu

Ovidius University

A regular version of the extremal RN spacetime

A modified extremal Reissner-Nordstrom geometry, void of singularities, is proposed in this work, by means of an exponential factor depending on a positive constant k. All the metric coefficients are positive and finite and the spacetime has no any horizon. The curvature invariants are regular at the origin of coordinates and at infinity. The energy conditions for the stress tensor associate to the imperfect fluid are investigated. The gravitational field presents repulsive properties near the gravitational radius associated to the mass m. With the choice $k = 1/m$, the Komar energy WK of the mass m changes its sign at $r = \lambda$ (λ is the Compton wavelength of m), when the classical energy mc2 equals the energy $\hbar c/r$.

Renjie Feng

Bielefeld University

Determinantal point processes on spheres: multivariate linear statistics

We will derive a graphical representation for the cumulants of multivariate linear statistics for any determinantal point process, which generalizes the famous formula by Soshnikov. As an application, we Will derive the 1st and 2^{nd} Wiener chaos for the multivariate linear statistics of the determinantal point processes associated with the spectral projection kernels on the unit spheres S^d.

Onirban Islam

Potsdam Universität

A Gutzwiller trace formula for Dirac operators on a stationary spacetime

A Duistermaat–Guillemin–Gutzwiller trace formula for Dirac-type operators on a globally hyperbolic spatially compact stationary spacetime is achieved by generalising the recent construction by Strohmaier and Zelditch (Adv Math 376:107434, 2021) to a vector bundle setting. We have analysed the spectrum of the Lie derivative with respect to a global timelike Killing vector field on the solution space of the Dirac equation and found that it consists of discrete real eigenvalues. The distributional trace of the time evolution operator has singularities at the periods of induced Killing flow on the space of lightlike geodesics. This gives rise to the Weyl law asymptotic at the vanishing period.

Omar Kidwai

Sheffield University

Voros symbols of quantum curves and the BPS Riemann-Hilbert problem

Bridgeland formulated a Riemann-Hilbert type problem valued in a group of automorphisms of a certain torus, which plays an important role in the study of stability conditions, Donaldson-Thomas theory, and four dimensional supersymmetric QFTs. We show how to solve this problem in simple cases using topological recursion, which arises in a totally different context. A key role is played by the WKB analysis of the resulting "quantum curve".

Joseph Lap

Yale University

Hadronization: Another Information Paradox

There has been much progress recently in resolving the black-hole information paradox. Part of the story has been the use of novel techniques for calculating the entanglement entropy of the boundary CFT via minimal surfaces in the bulk AdS space (the so-called Ryu-Takayanagi Formula). We argue that the QCD process of hadronization - in which hadrons are formed out of the quark-gluon plasma- constitutes a related information paradox. We study the thermalization properties of the QGP via calculations in its dual gravitational theory.

Sid Maibach

Bonn University

The semigroup of annuli

TBA

Thomas Müller

Labri Bordeaux

Double scaling limit of the prismatic tensor model

We study here the diagrammatics and the double scaling limit of this model, using the intermediate field method. We explicitly exhibit the next-to-leading order Feynman graphs in the $1/N$ expansion. Using appropriate combinatorial tools, we further study the general term of the $1/N$ expansion and we compute the 2-point function in the double scaling limit.

Nathan Pagliaroli

University of Western Ontario

Double scaling limits of Dirac ensembles and Liouville quantum gravity

In this work we study ensembles of finite real spectral triples equipped with a path integral over the space of possible Dirac operators. In the noncommutative geometric setting of spectral triples, Dirac operators take the center stage as a replacement for a metric on a manifold. Thus, this path integral serves as a noncommutative analogue of integration over metrics, a key feature of a theory of quantum gravity. From these integrals in the so-called double scaling limit we derive critical exponents of minimal models from two dimensional Liouville conformal field theory coupled with gravity. Additionally, the asymptotics of the partition function of these models satisfy differential equations such as Painlevé I, as a reduction of the KDV hierarchy, which is predicted by conformal field theory. This is all proven using well-established and rigorous techniques from random matrix theory.

David Prinz

MPIM Bonn

Gauge symmetries and renormalisation

We study the perturbative renormalization of quantum gauge theories in the Hopf algebra setup of Connes and Kreimer. It was shown by van Suijlekom (2007) that the quantum counterparts of gauge symmetries – the so-called Ward–Takahashi and Slavnov–Taylor identities – correspond to Hopf ideals in the respective renormalization Hopf algebra. We generalize this correspondence to super- and non-renormalizable Quantum Field Theories, extend it to theories with multiple coupling constants and add a discussion on transversality. In particular, this allows us to apply our results to (effective) Quantum General Relativity, possibly coupled to matter from the Standard Model, as was suggested by Kreimer (2008). To this end, we introduce different gradings on the renormalization Hopf algebra and study combinatorial properties of the superficial degree of divergence. Then we generalize known coproduct and antipode identities to the super- and non-renormalizable cases and to theories with multiple vertex residues. Building upon our main result, we provide criteria for the compatibility of these Hopf ideals with the corresponding renormalized Feynman rules. A direct consequence of our findings is the well-definedness of the Corolla polynomial for Quantum Yang–Mills theory without reference to a particular renormalization scheme.

Jinwoo Sung

Chicago University

The Minkowski content measure for the Liouville quantum gravity metric

A Liouville quantum gravity (LQG) surface was formulated geometrically as initally a random measure space and later as a random metric space. We show that the LQG measure can be recovered as the Minkowski measure with respect to the LQG metric, answering a question of Gwynne and Miller (2019). As a consequence, we prove that the metric structure of a γ-LQG surface determines its conformal structure for every $\gamma \in (0, 2)$. Our primary tool is the continuum mating-of-trees theory for space-filling SLE.

Johannes Thürigen

WWU Münster

Random geometry from tensor fields

TBA

Catherine Wolfram

MIT

Large deviations for the 3D dimer model

A dimer tiling of $\mathbb{Z}^d$ is a collection of edges such that every vertex is covered exactly once. In 2000, Cohn, Kenyon, and Propp showed that 2D dimer tilings satisfy a large deviations principle. Loosely speaking, this means that given a simply connected region R in the plane and a sequence of finer and finer grid regions R_n approximating R, random tilings of R_n converge to a deterministic "limit shape." The poster would present how to formulate and prove an analogous large deviations principle for dimers in 3D, with new methods and without exact solvability. This is joint work with Nishant Chandgotia and Scott Sheffield.

Bart Zonneveld

Radboud University

Topological recursion on hyperbolic surfaces with defects

TBA