WWU
MÜNSTER

From Perturbative to Non-Perturbative QFT

June 14 – 16, 2023
Münster

Book of Abstracts

Organisers

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MM Mathematics Münster
Cluster of Excellence

Schedule
From perturbative to non-perturbative QFT
June 14 – June 16, 2023

Wednesday	
09:00 – 09:50	Nguyen Viet Dang
09:50 – 10:20	Coffee break
10:20 – 11:10	Alexander Hock
11:10 – 11:30	Break
11:30 – 12:20	Sabine Harribey
12:20 – 14:00	Lunch
14:00 – 14:50	Vincent Rivasseau
14:50 – 15:20	Coffee break
15:20 – 16:10	Léonard Ferdinand
16:10 – 16:30	Break
16:30 – 17:20	Thomas Krajewski
17:20 – 17:30	Break
17:30 – 18:20	Zhituo Wang
18:30 – 21:00	Reception: Wine + Cheese SRZ Foyer 2nd floor

Thursday	
09:00 – 09:50	Roberto Percacci
09:50 – 10:20	Coffee break
10:20 – 11:10	Astrid Eichhorn (online)
11:10 – 11:30	Break
11:30 – 12:20	Joseph Ben Geloun
12:20 – 14:00	Lunch
14:15 – 15:15	David Broadhurst M4
15:15 – 15:45	Coffee break
15:45 – 16:35	Michael Borinsky
16:35 – 16:50	Break
16:50 – 17:40	Dario Benedetti

Friday	
09:00 – 09:50	Luca Lionni
09:50 – 10:15	Coffee break
10:15 – 11:05	Sylvain Carrozza
11:05 – 11:15	Break
11:15 – 12:05	Antonio Duarte Pereira (online)
12:05 – 12:15	Break
12:15 – 13:05	Reiko Toriumi

General information

Venue. The main workshop venue is the MM-conference center located on the second floor of the Seminarraumzentrum (SRZ) at Orléans-Ring 12, 48149 Münster (see map on p. 4). You will find the registration there. Moreover, the coffee breaks take place in the lounge of the seminar building SRZ (second floor) right in front of the seminar room.

You can find the latest information on the webpage:
www.uni-muenster.de/MathematicsMuenster/events/2023/QFT.shtml

Wi-Fi access. If you are part of the eduroam community, you may connect to the network "eduroam" as usual. Otherwise you can connect to the SSID "GuestOnCampus" and start any web browser. You will automatically be redirected to the login page. Confirm the terms of use and click on "log in for free". 1 GB data volume is available per device and day. Please note that the connection is not encrypted.

Reception. There is a Wine + Cheese reception for all participants of the workshop on Wednesday evening starting at 18:30 in the lounge of the MM-conference center (Seminarraumzentrum (SRZ), second floor, Orléans-Ring 12).

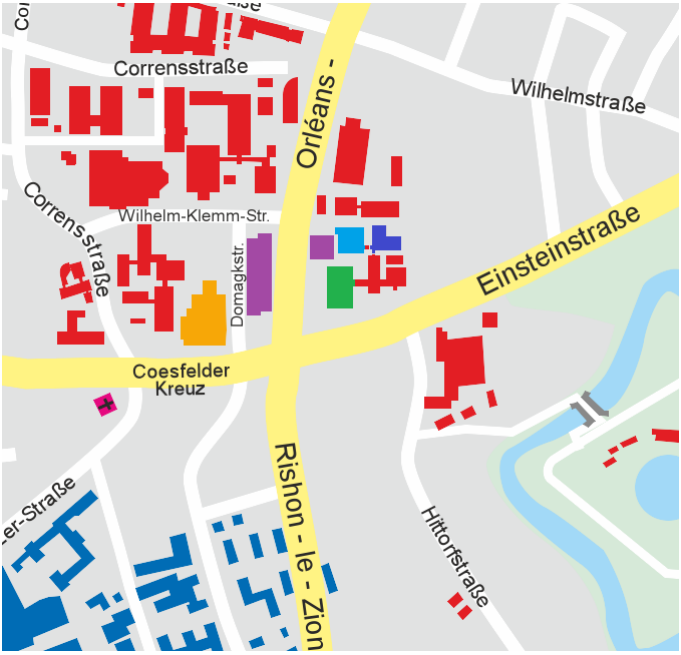
Coffee break/Lunch. We provide coffee and snacks during the coffee breaks.

There are a couple of restaurants for lunch in the vicinity:

- Canteen – Mensa am Ring, Domagkstraße 61 (all speakers receive vouchers (1 meal + 1 drink per day) for the canteen during registration)
- Ristorante Milano (Italian), Wilhelmstraße 26 (closed Mondays)
- King Kebab (Fast Food), Corrensstraße 80
- Il Gondoliere (Italian), Von-Esmarch-Straße 28 (closed Mondays)
- Buddha Palace (Indian), Von-Esmarch-Straße 18 (closed Tuesdays)
- La Gondola D'oro (Italian), Hüfferstraße 34
- Gustav Grün (Green Fast Food), Wilhelmstraße 1
- Áro (Green Fast Food), Neutor 3

Public transportation. You can check the bus schedule on the website of Stadtwerke-Münster (in German and English), or use Google maps.

Questions. In case of further questions, please use:
Email: g.dierkes@uni-muenster.de



SRZ (workshop venue, 2nd floor)
Math Department
canteen
multi-storey car park.

Book of abstracts

Old and new conformal field theories at large N

Dario Benedetti Thu 16:50

The $1/N$ expansion is a well established approach to studying interacting fixed points of the renormalization group, and the associated conformal field theories. In this talk, I will review old and new results on the conformal limit of the O(N) (vector) and O(N)^3 (tensor) models at large N.

Tensor Field Theory with local and nonlocal degrees of freedom: Phase Transition from the FRG Approach

Joseph Ben Geloun Thu 11:30

We apply the Functional Renormalization Group analysis to Tensor Field Theory (TFT) endowed with both local and nonlocal degrees of freedom and in the cyclic "melonic" truncation. For simplicity, we concentrate on the so-called local potential approximation without inspecting the flow of the wave function renormalization. A notion of effective dimension $d_{eff} = d+(r-1)/\zeta$ is identified from the dimension of our configuration space $R^d \times G^r$ where G is a compact Lie group and ζ is one of our theory parameters. The compact dimensions vanish along the flow yielding, in the IR limit, $d_{eff} = d$. This positively allows phase transition in TFT as soon as $d > 2$. Due to the richness of the TFT model, we examine the phase structure of sundry limiting situations.

Probing the non-perturbative regime with tropical Feynman integration

Michael Borinsky Thu 15:45

Feynman integrals are complicated objects and it is generally hard to evaluate them analytically. However, if their inherent mathematical structure is fully put to use, these integrals turn out to be remarkably well-suited for numerical evaluation. Feynman integrals with up to 30 propagators can be integrated quickly. I will illustrate how these tropical geometric structures can be employed, explain the key algorithmic step, tropical sampling, in detail and show first empirical results on the large loop behaviour of the beta function in $D = 4$ phi^4 based on numerical computations up to 15 loops.

Taming unsummable series

David Broadhurst Thu 14:15

Quantum field theorists often resort to perturbative expansions in a reasonably small parameter. Yet these may have no radius of convergence. Summation of sign-alternating asymptotic series is sometimes achievable by Borel transformation, which may be improved by Pade approximations. I shall give an example that yields to these methods. The less tractable sign-constant case occurs in condensed-matter problems. Here, Michael Borinsky and I have developed a trans-series. This is a formal expansion in powers of x, $\exp(-1/x)$ and $\log(x)$, with coefficients whose asymptotic growth is determined by further terms in the trans-series, and so on, ad infinitum.

TBA

Sylvain Carrozza Fri 10:15

TBA

Fixing the gauge-fixing procedure: a non-perturbative concern

Antonio Duarte Pereira Fri 11:15 (online)

The treatment of gauge theories in the continuum typically requires the introduction of a gauge-fixing condition. In perturbation theory, the ingenious Faddeev-Popov trick is widely used allowing for the explicit evaluation of gauge fields propagators. However, in strongly-coupled regimes, the assumptions behind the Faddeev-Popov construction do not hold. Gauge fields that fulfil the gauge condition and are connected by gauge transformations are still present in the configuration space - they are the so-called Gribov copies. In this talk, I will present an overview of the problem together with recent developments on how to deal with gauge copies in practice. Most of the presentation will be focused on Yang-Mills theories, but comments that are relevant for the quantum-field theoretic formulation of quantum gravity will be made whenever possible.

How perturbative does quantum gravity need to be?

Astrid Eichhorn Thu 10:20 (online)

The perturbative nonrenormalizability of the Einstein-Hilbert action is often taken as a hint that a quantum field theory of gravity should be non-perturbative, and asymptotically safe quantum gravity is often viewed as an example. In this talk, I will present indications that asymptotically safe quantum gravity with matter is instead near-perturbative and I will discuss implications, both for the control of approximations as well as for the relation of Euclidean to Lorentzian-signature settings.

The small-N series in the zero-dimensional O(N) model

Razvan Gurau Mon 11:30

I will discuss the application of some constructive field theory inspired techniques to the study of resurgence in the 0 dimensional O(N) model and its small N limit. This is the first step in the program of applying such techniques to fully fledged higher dimensional quantum field theory.

Extraordinary Interfaces and Boundaries in 4-epsilon dimensional O(N) models

Sabine Harribey Wed 11:30

The critical O(N) models are one of the most thoroughly studied classes of conformal field theories (CFTs) in three dimensions. Indeed, there exists a variety of approximation methods applicable to them, such as epsilon expansion, large N expansion or conformal bootstrap. It is then of interest to study the three dimensional O(N) models with interfaces (co-dimension one defects), as well as on spaces with boundaries. In particular, we are interested in "extraordinary" critical interfaces and boundaries which break the O(N) symmetry to O(N-1). Such models were studied recently with a D dimensional bulk and surface defects quadratic in the fields. In this talk, we will adopt a different approach and study defects that are always of co-dimension one. More precisely, I will present the renormalisation group analysis for a quartic O(N) model in 4-epsilon dimensions with cubic interactions on an interface. For sufficiently large N, we find stable IR fixed points with purely imaginary cubic couplings. I will also review the special case N=1 corresponding to a boundary Yang-Lee model.

Non-perturbative results of a just-renormalisable model

Alexander Hock Wed 10:20

We consider the scalar ϕ^4 model on the 4-dimensional noncommutative Moyal space. This is the critical dimension where the model becomes just-renormalisable. At the self-dual point, this model breaks down to a matrix model, where the noncommutativity of the underlying space is related to the size N of the matrix. Assuming a formal expansion in $1/N$, the Dyson-Schwinger equations (after applying Ward identities) decouple which leads to (non-)linear integral equations at each order in $1/N$. We will present and discuss from different perspectives the leading order (genus $g = 0$) result of the 2-point function, which is a resummation of infinitely many Feynman diagrams. We will also discussion the Hopf-algebraic renormalision of this model in the sense of Connes-Kreimer, which has the same complexitiy as an ordinary just-renormalisable QFT.

Loop vertex expansion for random matrices with higher order interactions

Thomas Krajewski Wed 16:30

The loop vertex expansion is an alternative to the standard Feynman graph expansion which trades the latter for a convergent expansion over trees. In this talk, we present the general framework and apply it to some random matrix models. As a byproduct, we establish analyticity in the coupling in a domain independent of the size of the matrix, as

well as Borel summability. This is based on work in collaboration with V. Rivasseau et V. Sazonov, see https://arxiv.org/abs/1910.13261.

On tensor invariants and entanglement

Luca Lionni Fri 9:00

Bubbles, tensor invariants, trace invariants, local unitary invariants… different names for the same polynomials that we know very well and like to picture in colors. I will talk about how these invariants appear naturally in the study of entanglement in quantum systems, and then discuss the following topics:

- the information contained in the dominant exponent of N of the tensor invariants;
- the information recovered at leading order from local randomized measurements (that is, the tensor HCIZ integral), depending on the ranks of the observables;

in both cases basing the discussion on a toy-model / example: an ensemble of density matrices for which the dominant exponents of the invariants resemble that of random tensor models.

Beta functions and scattering in a shift-invariant scalar theory

Roberto Percacci Thu 9:00

A single scalar with higher-derivative kinetic term and derivative quartic interactions is a toy model for higher derivative gravity. The Functional Renormalization Group shows that this theory is asymptotically free both in the UV and in the IR. The physical implications of this result are clarified in part by by computing the scattering amplitudes.

Random Tensors, Loop Vertex Representation and Cumulants

Vincent Rivasseau Wed 14:00

First of all, I briefly discuss the tensor track, a particular approach to quantum gravity based on random tensors. Then I review the Loop Vertex Representation (LVR), which combines combinatorial tools such as the BKAR formula, selective Gaussian integration, and the Fuss-Catalan generating function. In the last part I apply this LVR to obtain convergent expansions for the cumulants of matrix models.

Renormalisation of enhanced quartic tensor field theories

Reiko Toriumi Fri 12:15

Tensor field theory is the quantum field theoretic counterpart of tensor models. One may "enhance" certain interactions which are not of conventional melonic type so that they contribute to the dominant amplitudes, which consequently may drive us away from the branched polymer phase characterised by the usual melonic limit of tensor models. Therefore, such enhanced tensor field theories are of interest for the random geometric approach to quantum gravity. We consider two types of enhanced models + and × with order-d tensor fields $\phi : (U(1)^D)^d \to \mathbb{C}$ and with the enhanced quartic interactions of the form $p^{2a}\phi^4$ reminiscent of derivative couplings expressed in momentum space. Scrutinising the degree of divergence via multiscale renormalisation analysis, we study their renormalisability at all orders of perturbation. We furthermore compute the beta functions of the couplings to understand their renormalisation group flow behavior. At all orders of perturbation, both models have a constant wave function renormalisation, therefore no anomalous dimension. Despite such a peculiar behavior, both models acquire nontrivial radiative corrections for the coupling constants. In particular, we observe in some of the coupling constants linear behavior in the log of momentum.

Constructive renormalizations in Quantum Many-body system

Zhituo Wang Wed 17:30

In this talk I will present some recent progress on the construction of ground state of the 2-dimensional Hubbard model, which is a prototypical model for studying phase transitions in quantum many-body system. Using fermionic cluster expansions and constructive renormalization theory, we proved that the ground state of the 2-d Hubbard model on the honeycomb lattice with triangular Fermi surfaces is not a Fermi liquid in the mathematical precise sense of Salmhofer. I will also discuss the crossover phenomenon in the 2-d square Hubbard model and universalities. This presentation is based on the work arXiv:2108.10852 and arXiv:2303.13628.

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