PROGRAM YOUNG SPEAKERS

DIRK

Speakers, titles and abstracts

- **Session I (14:00-14:30, 14:35-15:05, 15:10-15:40)**
  - Kay Schoenwald::

    Two-mass, 3-loop effects for heavy flavor deep inelastic scattering

    In this talk I will review the recent calculations of the effects of simultaneously considering the charm and bottom quark in deep inelastic scattering at three loop order. This is necessary, since the charm quark cannot be considered massless at the scale of the bottom quark. The review will cover the phenomenological implications at two loop order, the computational strategies for the calculations at three loop and an overview of the mathematical structures encountered.

  - Marcel Golz:

    Parametric QED

    The Schwinger parametric Feynman integral has long been an enormously useful tool in physics and in recent years it has also attracted numerous mathematicians due to its connections to algebraic geometry. However, when moving from the scalar case to gauge theories they quickly become prohibitively complicated due to the additional tensor structure (e.g. Dirac matrices in quantum electrodynamics) and very involved numerator polynomials. I report on recent progress made toward simplification via combinatorics for the case of QED. In the end, the integrand is only a very small sum of scalar integrands with numerators consisting of the well-known Dodgson polynomials.

  - Konrad Schultka:

    Toric Varieties for Feynman Integrals

Feynman integrals in euclidean kinematics can be conveniently expressed in the parametric representation as a projective integral. For certain applications, such as arithmetic questions or sector decompositions, one should replace the ambient projective space by certain toric varieties, which are better adapted to the vanishing sets of the Symanzik polynomials. After brie y sketching the theory of toric geometry, I show that one should consider the Newton polytope of the product of the Symanzik polynomials and look for smooth refinements of its normal fan. For Feynman graphs with euclidean kinematics, the Newton polytope can be explicitly calculated and I sketch the construction of various smooth refinements of its normal fan given by combinatorial data. As special cases one obtains the motic blowup of Brown and the original Bloch-Esnault-Kreimer construction. The sector decompositions of Speer and Smirnov can also be translated into this language.

- **Session II (16:15-16:45, 16:50-17:20, 17:25-17:55)**

  – Mahendraprasad Mali

    Aspects of gravity in light-cone gauge

    Abstract: The formulation of quantum field theory of gravity results in divergences which are difficult to treat. This rules out any straightforward attempt to unite quantum theory and the general theory of relativity. However there are quite a few reasons for still studying gravity as a quantum field theory. There are surprising perturbative ties between gravity and Yang-Mills theory. These perturbative ties link tree-level amplitudes of gravity and Yang-Mills theory on flat backgrounds. We have formulated perurbative gravity Lagrangian on curved backgrounds (such as AdS_4 and dS_4) in order to check the existence of such relations on curved backgrounds. A second theme for my talk relates to supergravity. It is surprisingly well behaved and this indicates the possibility of hidden mathematical structures in the theory. Further, its Hamiltonian can be written as a quadratic form. It has been observed that such forms exist also in pure gravity.

  – David Prinz:

    Einstein-Maxwell-Dirac-Theory and perturbative Quantization

    Einstein-Maxwell-Dirac-Theory is the canonical generalization of spinor electrodynamics to curved spacetimes of general relativity. In this talk, I first explain the underlying geometry of the theory and then introduce its Lagrange density. In order to allow for perturbative quantization, this includes in particular the gauge fixing and ghost terms. Then I motivate the corresponding Feynman rules and tree-level interactions. Finally, I address one of the obstructions to multiplicative renormalization and then show how it can be overcome by a generalization of Furry's theorem.

– Song He:

Conformal boostrap to Entanglement in 2D conformal field theory

The abstract: We study the entanglement entropy of excited states in two-dimensional conformal field theories (CFTs). In particular, we consider excited states obtained by acting on a vacuum with primary operators. We show that the entanglement entropy increases by a finite constant amount under its time evolution. Moreover, in rational conformal field theories, we prove that this increase of the (both Renyi and von Neumann) entanglement entropy always coincides with the log of the quantum dimension of the primary operator in rational CFTs. Finally, we extend to irrational CFTs, Especially in Liouville field theory and Super Liouville field theory.

- **Session III (14:00-14:30, 14:35-15:05, 15:10-15:40)**

– Maximilian Muehlbauer:

Homology of Moduli Spaces of Colored 1-Loop Feynman Graphs

Abstract
Determining the analytical structure of Feynman integrals is a time-honored problem. Recent considerations have brought to attention that certain moduli spaces of graphs derived from Outer space may hold interesting insights into this matter. To obtain physical results, graph edges have to be endowed with additional data which can be achieved by a coloring of the edges to function as a placeholder for such data. A first step to understand such moduli spaces of colored graphs is the computation of their homology. For the case with rational coefficients, the homology groups can be calculated directly. Additionally to a large number of explicit generators for the one-loop case, a few particular groups are determined in more generality.

- Iain Crump:

  The Graph Permanent

  The graph permanent is a graph invariant constructed as a sequence of residues over a certain subset of primes. It is known to be invariant under the four operations known to preserve the period. Calculations at low loop orders suggest that the permanent is particularly varied, though there are some examples of graphs with unequal periods but (likely) equal permanents. Data suggests, though, that the permanent and c2 invariant may work well together.

- Dmitry Doryn:

  Completion conjecture in position space for $p = 2$.

  Abstract: Completion conjecture is the most interesting unproved fact in the arithmetics of graph hypersurfaces. I want to talk on an alanogue of this conjecture in position space, namely, on the proof of completion invariance for the c_2 invariant c_2^{pos} in the case p=2.

- **Session IV (16:15-16:45, 16:50-17:20, 17:25-17:55)**

  - Paul Balduf:

    Diffeomorphisms of quantum fields

    Abstract: If in a Lagrangian density the scalar fields phi are replaced by a diffeomorphism $\phi = rho + a_1 rho^2 + ...$, the so-defined Lagrangian density of the field rho contains monomials of any order even if the original Lagrangian density was free of interaction. By Feynman rules, an infinite set of new "diffeomorphism"-vertices emerge. Althought complicated on first sight, the amplitudes of these vertices are such that they cancel adjacent propagators and effectively eliminate each other in a specific sense: The onshell n-point functions are unchanged regardless of the diffeomorphism applied. This was established by Kreimer and Yeats in 2017. The S-matrix is unchanged even if the original Lagrangian contains an interaction term. This opens the possiblity to choose amongst all diffeomorphism-equivalent fields one with desirable properties regarding e.g. its offshell correlation functions (which are affected by the diffeomorphism). Indeed, the diffeomorphism parameters can be chosen such that for a given external momentum in kinematic renormalization all correction Feynman diagrams with 2 external legs vanish, i.e. the offshell 2-point function of the field rho resembles the one of a free scalar quantum field.

– Alexander Hock

Noncommutative 3-colour scalar quantum field theory model in 2D

Abstract We introduce the 3-colour noncommutative quantum field theory model in two dimensions. For this model we prove a generalised Ward-Takahashi identity, which is special to coloured noncommutative QFT models. It reduces to the usual Ward- Takahashi identity in a particular case. The Ward-Takahashi identity is used to simplify the Schwinger-Dyson equations for the 2-point function and the N -point function. The absence of any renormalisation conditions in the large (N , V)-limit in 2D leads to a recursive integral equation for the 2-point function, which we solve perturbatively to sixth order in the coupling constant.
One important fact is the appearance of polylogarithms in the perturbative solution, which is generated by the closed integral equation. With the knowlegde of the experts here in Les Houches I hope to improve my results to higher order or even find an exact solution for the 2-point function.

– Johannes Thuerigen:

Loop equations in tensorial theories
Abstract: Tensor field theories/models generalize the matrix-model approach to 2d quantum gravity to higher dimensions. Loop observables generalize to traces of field polynomials characterized by tensor invariance. At leading order in the 1/N expansion these observables are the generating functions of diagrams in the perturbative expansion. Thus, the derivation of Dyson-Schwinger loop equations reduce to a combinatorial counting problem. In this talk I derive these loop equations for all rank-4 tensors with quartic and sextic interactions. An analysis of the critical behaviour of their solutions unveils a generic phase diagram of a branched-polymer and a 2d planar phase. (based on arXiv:1707.08931)