ECT* Workshop

Mathematical Aspects of Hadron Physics

October 8-12, 2012

Program

Titles and Abstracts **(in alphabetical order)**

1. Jakob ABLINGER (DESY, Germany)

Nested Sums and Iterated Integrals in QCD

In this talk we will present algorithms for indefinite nested sums like, e.g., harmonic sums, S-sums or cyclotomic sums that play an important role in Quantum field theory. Special emphasis will be put, e.g., on algebraic relations of these sums and on algorithms that compute the asymptotic expansion of such objects. In addition we will treat iterated integrals of the Poincaré -type, such as harmonic polylogarithms and their generalizations (multiple polylogarithms, cyclotomic harmonic polylogarithms). These iterated integrals are connected to the nested sums via (generalizations of) the Mellin-transformation and we show how this transformation can be computed. We will consider relations between the values of the nested sums at infinity and connected to it the values of the iterated integrals evaluated at special constants. Moreover we summarize the main functionality of the computer algebra package `HarmonicSums` in which all these algorithms and transformations are implemented.

2. Adnan BASHIR (Michoacan, Mexico)

Tba

TBA

3. Marc BELLON (CNRS, Paris 6, France)

Schwinger–Dyson equations: from abstract combinatorics to concrete computations

Through the introduction of sub-Hopf algebras of the Hopf algebra of graphs presented in preceding introductory talks, we show how complicated combinatorics can be proved with some simple formal computation. In particular, a version of the renormalization group provides tools for the efficient solution of a Schwinger–Dyson equation for the propagator.

4. Romeo BRUNETTI (Trento, Italy)

Tba

TBA

5. Kurusch EBRAHIMI-FARD (ICMAT, Madrid, Spain)

Hopf algebra and Feynman graphs – II

This talk is a sequel of Frederic Patras' talk. Recall that in 1957 Bogoliubov and Parasiuk described a concise method for renormalization in pQFT. Later Hepp and Zimmermann further improved the Bogoliubov-Parasiuk method, culminating in the BPHZ renormalization method. Based on Dirk Kreimer's findings, Alain Connes and Kreimer developed a Hopf algebraic approach to the BPHZ renormalization method in pQFT. It enabled them to encode its essential combinatorial and algebraic aspects. The process of renormalization is captured by a factorization theorem for regularized Hopf algebra characters. We will review this result in detail. If time permits, we will briefly report on recent joint work with Patras on a new perturbative renormalization method, developed in the context of Connes-Kreimer's Hopf algebra of Feynman graphs. Due to its form we dubbed it "exponential" method. Using Dyson's identity for Green's functions as well as the link between the Faà di Bruno Hopf algebra and Hopf algebras of Feynman graphs, its relation to the composition of formal power series is analyzed. This leads to the introduction of the notion of counterfactors and order n bare coupling constants. Eventually we analyze the role of the Rota–Baxter property for renormalization scheme maps.

6. Thierry GRANDOU (CNRS, Nice, France)

Tba

TBA

7. Joachim KOCK (Barcelona, Spain)

Groupoids and polynomial functors in the combinatorics of Quantum Field Theory

Groupoids generalise both sets and groups, and are very useful to deal with combinatorial problems involving symmetries. The main point of this talk is the insight that sums weighted by symmetry factors can be seen as relative homotopy cardinalities of groupoids, and that manipulation with such series can be interpreted as constructions with groupoids. This viewpoint reveals some notions in the combinatorics of Quantum Field Theory to be special cases of more general constructions of wider interest. For example, (combinatorial) Green functions as solutions to (combinatorial) Dyson-Schwinger equations can be seen as an instance of the general fact that if P is a polynomial endofunctor over groupoids, then its least homotopy fixpoint is the groupoid of P-trees (a result originating in theoretical computer science, where it is the standard approach to inductive data types). Rather than going into technical details, I hope to convey the overall ideas by starting gently with some basic facts about groupoids and homotopy cardinality, then introduce polynomial functors and explain their relationship with trees, and finally give examples of polynomial endofunctors P and their corresponding P-trees motivated by QFT.

8. Thomas KRAJEWSKI (Marseille, France)

Schwinger-Dyson equations in the group field theory formulation of quantum gravity

Constructing a quantum theory of gravity remains one of the most tantalizing open problem in theoretical physics. After a brief overview of the problem, we present group field theory which combines the combinatorics of (generalized) matrix models and the spin foam amplitudes derived from canonical quantization. The group field theory Schwinger-Dyson equations yield some constraints on the quantum gravity amplitudes which define a Lie algebra. This Lie algebra is related to a Hopf algebra structure on the Penrose spin networks (graph whose edges are decorated by spins and vertices by intertwiners).

9. Giovanni LANDI (Trieste, Italy)

Noncommutative geometry: Gravity, Standard Model, and All That

TBA

10. Frederic PATRAS (CNRS, Nice, France)

Hopf algebra and Feynman graphs – I

The talk will recall the links between Hopf algebras and groups, emphasizing two meaningful cases for QFT: formal power series and their substitutions (the Faà di Bruno Hopf algebra) and Feynman rules with the product law induced by the Bogoliubov recursion formula (the Hopf algebra of Feynman graphs).

11. Michael PENNINGTON (Jefferson Lab., Newport News, USA)

Dyson–Schwinger equations & multiplicative renormalizability

Tba

12. Adrian QUADRI (INFN, Milano, Italy)

Canonical transformations in (non-pert.) gauge theories with non-trivial backgrounds

TBA

13. Craig ROBERTS (ANL, USA)

Truncations in Dyson–Schwinger equation QCD

Quantum Chromodynamics (QCD) is the most interesting part of the Standard Model of Particle Physics because it is essentially nonperturbative. The perturbatively constructed renormalisation group is inapplicable to the most basic features of the theory; viz., confinement and dynamical chiral symmetry breaking, which both place an indelible stamp on the universe we live in. These phenomena will be explained and their impact illustrated using the Dyson–Schwinger equations. In doing so, the problem of nonperturbative truncation will also be stated and practicable methods described.

14. Jose RODRIGUEZ-QUINTERO (Huelva, Spain)

Tba

TBA

15. Adrian TANASA (Paris 13, France)

Combinatorial Dyson–Schwinger equations in noncommutative field theory

After a brief recall of the commutative case, I give in this talk the Hopf algebra structure describing the noncommutative renormalization of a recently introduced translation-invariant model on Moyal space. I then define Hochschild one-cocyles B_+ which allows us to write down the combinatorial Dyson–Schwinger equations for noncommutative quantum field theory. One- and two-loops examples will be explicitly given. In the last part of the talk I will briefly introduce some tensor generalizations of these noncommutative (and hence matricial) models.

16. Peter TANDY (Kent, USA)

Tba

TBA

17. Jeremie UNTERBERGER (Nancy, France)

The BS kernel in condensed matter physics

This will be a pedagogical, self-contained lecture on the BS kernel in condensed matter physics, following the book by Fetter and Walecka.

18. Stefan WEINZIERL (Mainz, Germany)

Algebraic geometry meets particle physics

In this talk I will discuss how ideas from algebraic geometry can be used to derive differential equations for Feynman integrals.

Schedule

Monday, Oct. 8

– 09:30-11:00	**Patras**
– 11:00-11:30	—Coffee—
– 11:30-12:30	**Ebrahimi-Fard**
– 12:30-14:30	—Lunch and discussion—
– 14:30-16:00	**Roberts**
– 16:00-16:30	—Coffee—
– 16:30-17:30	**Tandy**

Tuesday, Oct. 9

– 09:30-11:00	**Bellon**
– 11:00-11:30	—Coffee—
– 11:30-12:30	**Krajewski**
– 12:30-14:30	—Lunch and discussion—
– 14:30-16:00	**Pennington**
– 16:00-16:30	—Coffee—
– 16:30-17:30	**Bashir**

Wednesday, Oct. 10

– 10:00-11:00	**Weinzierl**
– 11:00-11:30	—Coffee—
– 11:30-12:30	**Landi**
– 12:30-14:30	—Lunch and discussion—
– 15:00-16:00	**Quadri**
– 16:00-16:30	—Coffee—
– 16:30-17:30	**Tanasa**

Thursday, Oct. 11

– 10:00-11:00	**Ablinger**
– 11:00-11:30	—Coffee—
– 11:30-12:30	**Grandou**
– 12:30-14:30	—Lunch and discussion—
– 15:00-16:00	**Rodriguez-Quintero**
– 16:00-16:30	—Coffee—
– 16:30-17:30	**Brunetti**

Friday, Oct. 12

– 10:00-11:00	**Kock**
– 11:00-11:30	—Coffee—
– 11:30-12:30	**Unterberger**
– 12:30-14:30	—Lunch and discussion—