Timetable

Workshop on Multi-loop Calculations: Methods and Applications

Tuesday 14 and Wednesday 15 of May 2019

Tuesday May 14		
9:00 - 12:30	Tuesday morning	
	9:00 (*5'*)	Welcome
	9:10 (*40'*)	Stefan **Weinzierl** (Mainz U.) "Feynman integrals associated to elliptic curves"
	9:55 (*40'*)	Brenda **Penante** (CERN) "Elliptic polylogarithms and Feynman integrals"
	10:40 (*20'*)	Coffee break
	11:00 (*40'*)	Pierpaolo **Mastrolia** (Padova U.) "PN-Corrections to the Two-Body Dynamics and Feynman Calculus"
	11:45 (*40'*)	Simon **Badger** (Durham U.) "Analytic methods for two-loop amplitudes in QCD"
12:30 - 14:30	Lunch	
14:30 - 17:50	Tuesday afternoon	
	14:30 (*40'*)	Thibault **Damour** (IHES) "Multi-loops in Classical Gravity"
	15:15 (*40'*)	Mikhail **Solon** (Caltech) "Binary Black Holes and Gluon Scattering Amplitudes"
	16:00 (*20'*)	Coffee break
	16:20 (*40'*)	Emil **Bjerrum-Bohr** (NBIA) "Scattering Amplitudes and Results in General Relativity"
	17:05 (*40'*)	Luc **Blanchet** (IAP) "The Fokker action of compact binary systems at the fourth post-Newtonian order"
19:00	Workshop dinner	

Wednesday May 15		
9:10 - 12:30	Wednesday morning	
	9:10 (*40'*)	Dominique **Mouhanna** (LPTMC, Paris) "Statistical physics of polymerized phantom membranes"
	9:55 (*40'*)	Kay **Wiese** (LPTENS, Paris) "Field Theories for Loop-Erased Random Walks"
	10:40 (*20'*)	Coffee break
	11:00 (*40'*)	Mikhail **Kompaniets** (St Petersburg U.) "Borel resummation of the critical exponents (epsilon expansion vs conformal bootstrap) "
	11:45 (*40'*)	Alexander **Manashov** (Hamburg U.) "$1/N$-expansion: some recent results"
12:30 - 14:30	Lunch	
14:30 - 17:50	Wednesday afternoon	
	14:30 (*40'*)	Benjamin **Basso** (LPTENS) "Conformal fishnet graphs, their continuum limit and their deformations"
	15:15 (*40'*)	Oliver **Schlotterer** (Uppsala U.) "Elliptic multiple zeta values and modular forms in string amplitudes"
	16:00 (*20'*)	Coffee break
	16:20 (*40'*)	Michael **Green** (DAMTP & Queen Mary U.) "Modular properties of closed superstring theory scattering amplitudes"
	17:05 (*40'*)	Anatoly **Kotikov** (JINR, Dubna) "Critical properties of three-dimensional QED"
End of the Workshop		

Practical information:

- all talks will take place in Amphi Charpak, tower 22, level SB/RC,
- lunch breaks will take place in LPTHE, tower 13-14, 4th floor,
- the workshop dinner will take place in Tipi (entrance between towers 42 and 43, Jussieu level),
- the secretaries office is located in LPTHE, tower 13-14, 4th floor.

Amphi Charpak, tour 22, niveau SB/RC

Abstracts

Analytic methods for two-loop amplitudes in QCD

Simon Badger
Durham university

I will review the current status of 2 to 3 scattering amplitudes in QCD necessary for precision measurements at the LHC. There has been rapid progress making use of the reconstruction of rational functions from numerical evaluations over finite fields that sidesteps the traditional bottlenecks. Applications and future challenges will be discussed.

Conformal fishnet graphs, their continuum limit and their deformations

Benjamin Basso
LPTENS, Paris

I will review recent progress at computing planar conformal integrals of the fishnet type in $d = 4$ using integrability. This will cover applications to two- and higher-point functions. I will then discuss the large-order behaviour of fishnet graphs and make contact with Zamolodchikov's prediction for the critical coupling. I will argue that close to that point the fishnet graphs admit a continuum description in terms of the 2d non-linear AdS5 sigma model. If time permits I will discuss integrable deformations of the fishnet graphs.

Scattering Amplitudes and Results in General Relativity

Emil Bjerrum-Bohr
NBIA, Copenhagen

We discuss how to apply modern quantum field theory methods to calculate observables in classical general relativity.

The Fokker action of compact binary systems at the fourth post-Newtonian order

Luc Blanchet
Institut d'Astrophysique de Paris

The Fokker action of self-gravitating binary systems of point-particles is obtained at the fourth post-Newtonian (4PN) approximation of general relativity. The derivation is self contained within the post-Newtonian scheme, and the result is free of any ambiguity. Dimensional regularization is applied to treat both UV divergences (due to the model of point particles) and the IR divergences that appear specifically at the 4PN order.

Multi-loops in Classical Gravity

Thibault Damour
Institut des Hautes Études Scientifiques, Bures-sur-Yvette

We shall review the structure of multi-loop calculations in classical gravity from various points of view: post-Minkowskian, post-Newtonian, self-force, reduced action, effective one-body, UV/IR. We shall also discuss the (two-way) maps between classical dynamics and quantum amplitudes.

Modular properties of closed superstring theory scattering amplitudes

Michael Green
Queen Mary University of London & DAMTP, University of Cambridge

This talk will give an overview of the constraints imposed by duality and supersymmetry on the low energy expansion of scattering amplitudes of massless states in type IIB superstring theory.

Borel resummation of the critical exponents (epsilon expansion vs conformal bootstrap)

Mikhail Kompaniets
St.Petersburg State University

In perturbative approach critical exponents are calculated as asymptotic series and require resummtaion to get reliable predictions. We will discuss in detail different resummation techniques based on Borel transform. Results of the resummation is compared with values obtained by conformal bootstrap method for Ising universality class in various dimensions ($2 < d < 4$). We show that in wide region of space dimensions the values of exponents obtained by both methods systematically differs one from each other. Possible origins for this discrepancy and future directions of the investigation of the problem are discussed.

Critical properties of three-dimensional QED

Anatoly Kotikov
J.I.N.R., Dubna

The talk will focus on dynamical chiral symmetry breaking (DχSB) in $(2{+}1)$-dimensional QED with N four-component fermions. We shall present the recent exact next-to-leading order, in the $1/N$ expansion, solution for an arbitrary non-local gauge. The resummation of the wave-function renormalization constant at the level of the gap equation will be shown to yield a complete cancellation of the gauge dependence of the critical fermion flavour number resulting in: $N_c = 2.8469$, which is such that DχSB takes place for $N < N_c$.

$1/N$-expansion: some recent results

Alexander Manashov
Hamburg University & Steklov Math. Inst., St. Petersburg

I review a technique for calculating critical indices in $1/N$ expansion in QFT. Some results for scaling dimensions of higher-spin operators in the Gross-Neveu and nonlinear sigma models will be presented.

PN-Corrections to the Two-Body Dynamics and Feynman Calculus

Pierpaolo Mastrolia
University of Padova

I will review the diagrammatic approach for the determination of the post-Newtonian (PN) corrections to the gravitational potential of binary systems, within the effective field theory (EFT) framework for General Relativity. I will present its application to the determination of the static contributions up to 5PN, also discussing a factorization property of static PN corrections, which we recently formulated. I will conclude by introducing a novel method for multiloop Feynman calculus, which can be dramatically simplified by means of ideas borrowed from Differential Geometry and Algebraic Topology.

Statistical physics of polymerized phantom membranes

Dominique Mouhanna
LPTMC, Paris

Membranes and, more generally, random surfaces are ubiquitous in physics, ranging from high-energy physics to bio-physics. These last years polymerized membranes have known a strong renewed interest in condensed matter physics due to the discovery of extraordinary single layer carbon materials, like graphene, that are well modelized, as for their mechanical properties, by these systems. For practical reasons, notably the design of novel materials with optimized mechanical, optical and electronic properties, as well as from a more fundamental perspective, a well controlled field-theoretical description of these systems is highly needed. However physical, i.e. two-dimensional, polymerized membranes are, from the field-theoretical point of view, strongly interacting systems, far from their upper critical dimension four. This situation has lead to the use of many perturbative and nonperturbative methods resulting in contradicting predictions. In this talk I will present the state of the art as well as the recent developments of this subject.

Elliptic polylogarithms and Feynman integrals

Brenda Penante
CERN, Geneva

In this talk I discuss classes of function useful for representing Feynman integrals. The first, multiple polylogarithms (MPLs), constitute a well-understood class of functions which describe most of the Feynman integrals computed to date. Next I discuss a generalisation of MPLs to the elliptic curve suited for describing several integrals known not to be expressible in terms of MPLs. These functions generalise many of the interesting properties of MPLs, including the notion of uniform weight.

Oliver Schlotterer
Uppsala university,

This talk aims to illustrate recent connections between modern topics in number theory and one-loop scattering amplitudes in string theories. The low-energy expansion of one-loop string amplitudes introduces elliptic analogues of multiple zeta values for open-string scattering and modular forms for closed strings. By comparing the coefficients in the respective low-energy expansions, the modular forms from closed strings are observed to exhibit striking parallels to the elliptic multiple zeta values from open strings. These parallels are proposed to generalize the single-valued projection of multiple zeta values known from genus zero.

Binary Black Holes and Gluon Scattering Amplitudes

Mikhail Solon
Caltech, California, USA
address

We combine tools from the modern amplitudes program and effective field theory to develop a systematic and scalable method for deriving classical dynamics for binary systems from on-shell scattering. Applying this to gravitationally interacting massive scalars yields the first derivation of the conservative Hamiltonian for compact spinless binaries at third post-Minkowskian order. The resulting Hamiltonian is in complete agreement with corresponding terms in state-of-the-art expressions at fourth post-Newtonian order as well as the probe limit at all orders in velocity. Prospects for improving the accuracy of theoretical waveform templates employed in gravitational wave detection are discussed.

Feynman integrals associated to elliptic curves

Stefan Weinzierl
University of Mainz

Precision physics at the LHC requires higher-loop computations. Starting at two-loops, not every Feynman integral is expressible in terms of multiple polylogarithms. In this talk I will discuss Feynman integrals which are related to elliptic curves. These are the first Feynman integrals which go beyond the class of multiple polylogarithms.

Field Theories for Loop-Erased Random Walks

Kay Wiese
LPTENS, Paris

We analyze candidate field theories for loop-erased random walks (LERWs) in dimensions $2 \leq d \leq 4$. The first such candidate is ϕ^4-theory with $O(n)$-symmetry at $n = -2$. The link is established via a perturbation expansion in the coupling constant. The second candidate is a field theory for charge-density waves pinned by quenched disorder. Here the depinning transition is described by a non-analytic fixed point whose relation to the LERW had been conjectured earlier using analogies with Abelian sandpiles. We show diagrammatically order by order in the coupling constant that both theories yield identical results for key quantities such as the renormalization-group β-function, and the scaling dimensions of the observables which we identify with the fractal dimension of LERWs. While in ϕ^4 theory the latter is obtained from the crossover exponent encoded in the operator $\phi_1\phi_2$, in the charge-density-wave formulation it is given by the dynamical exponent z. The formal equivalence between the two theories is explicitly checked to 4-loop order. For the fractal dimension of LERWs in $d = 3$ it gives at 5-loop order $z = 1.624 \pm 0.002$, in agreement with the prediction $z = 1.62400 \pm 0.00005$ of numerical simulations. We also show that a minimal description of LERWs can be formulated in terms of complex fermions. These three models constitute a hierarchy of field theories for LERWs.