PARTICLEFACE 2019

Tuesday, 26 February 2019 - Thursday, 28 February 2019

Department of Physics (University of Coimbra)

Book of Abstracts

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Session 1 / **40**

Towards the precision frontier: dealing with QCD-QED corrections

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In this talk, we discuss some recent results related with highly-precise predictions for hadron colliders involving mixed QCD-QED effects. First, we explore fixed-order QED corrections, showing that the presence of extra-photon radiation leads to novel effects. Then, we describe a generalization of the q_T resummation/subtraction formalism to deal with photon-gluon radiation simultaneously. Using Z production as a benchmark example, we show that the inclusion of these higher-order corrections stabilizes the dependence of the final predictions on the arbitrary renormalization/factorization/resummation scales.

Session 1 / **63**

Quantum symmetry breaking in perturbation theory: physical or spurious?

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We discuss some subtleties related to the description of anomalies in quantum field theory using Feynman diagrams. Using a setup that operates in the physical dimension to regularize ultraviolet and infrared divergences, we establish some physical criteria to study quantum symmetry breaking. We illustrate with a few examples.

Session 1 / **42**

Gauge covariant approach to the electroweak interactions of spin-0 and spin-1 mesons

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An extended Nambu-Jona-Lasinio model with chiral group $U(2) \times U(2)$ and spin-0 and spin-1 four quark interactions is used to develop the gauge covariant approach to the diagonalization of the $\pi - a_1$ mixing in the presence of electroweak forces. This allows for manifestly gauge covariant description of both the non-anomalous and anomalous parts of the effective meson Lagrangian. It is shown that in the non-anomalous sector the theory is equivalent to the standard non-covariant approach. However, the theory differs from the standard one in the anomalous sector. Some straightforward applications are considered.

Session 1 / **44**

Reduction for special negative sectors of planar two-loop integrals

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In my talk I introduce an alternate way to perform reductions of special negative sectors of planar two-loop amplitudes using the Baikov representation. I will show that for the special negative sectors – where the inverse propagator factor appears in the numerator and contains both loop momenta – can be performed independently from all the other sectors resulting in a product of two one-loop tensor integrals rendering the remaining reductions much simpler when this configuration appears.

Session 2 / **46**

Uncovering new physics with precision

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The discovery of a Higgs boson in 2012 offers a new opportunity to explore physics beyond the Standard Model. Measuring the properties of the discovered Higgs boson and comparing the results to theory predictions can shed light on the underlying theory of nature. High experimental accuracy but also precise theoretical input are needed for this endeavour.

In the talk, I will discuss direct and indirect probes of the properties of the discovered Higgs boson in the context of different extensions of the Standard Model, for example the Higgs-boson decay in the Two-Higgs-Doublet Model at next-to-leading order.

Session 2 / **43**

Precise predictions for the $t\bar{t}\gamma/t\bar{t}$ cross section ratio at the LHC

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We study the ratio of the cross sections for $t\bar{t}\gamma$ and $t\bar{t}$ production at the LHC. We argue that, due to correlations between the theoretical uncertainties in the numerator and in the denominator, a very precise determination of this observable can be achieved at NLO QCD accuracy, with an uncertainty comparable to that of typical NNLO QCD computations. Thus, the ratio has an interesting potential to shed light on possible new physics that can reveal itself only when sufficiently precise theoretical predictions are available.
Our analysis is based on fully realistic NLO QCD simulations of $t\bar{t}\gamma$ and $t\bar{t}$ production in the dilepton decay channel, including complete off-shell effects and non-resonant contributions. Focusing on the case of the LHC at 13 TeV, we present numerical results for inclusive and differential cross section ratios. We also quantify the impact of the theoretical uncertainties related to renormalization/factorization scales as well as to different choices of parton distribution functions.

Session 2 / **59**

Universal four-dimensional representation of $H \to \gamma\gamma$ at two loops through the Loop-Tree Duality

Author: Félix Driencourt-Mangin[1]

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We extend useful properties of the $H \to \gamma\gamma$ unintegrated dual amplitudes from one- to two-loop level, using the Loop-Tree Duality formalism. In particular, we show that the universality of the functional form - regardless of the nature of the internal particle - still holds at this order. We also present an algorithmic way to renormalise two-loop amplitudes, by locally cancelling the ultraviolet singularities at integrand level, thus allowing a full four-dimensional numerical implementation of the method. Our results are compared with analytic expressions already available in the literature, finding a perfect numerical agreement. The success of this computation plays a crucial role for the development of a fully local four-dimensional framework to compute physical observables at the Next-to-Next-to Leading order and beyond.

Session 3 / **74**

E(38), new particle or artefact?

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Following our discovery of a significant signal in photon-photon data near 38 MeV, it was declared by the responsible Collaboration to be due to a detector artefact. We will show that the latter claim is not substantiated by the data simulation produced by the Collaboration and, moreover, present further experimental and theoretical results which support the existence of a boson lighter than the pion.

Session 3 / **41**

Indications of a (pseudo)scalar partner state of the Z boson at 57 GeV

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In 1995 the L3 collaboration observed an enhancement at 28 GeV in three-photon decays of the Z boson. Very recently, the CMS collaboration tentatively found an enhancement at the same energy in the invariant-mass distribution of muon pairs associated with a b-quark jet plus at least another jet. We interpret these signals not as the observation of an unknown resonance at 28 GeV, but rather as a possible new boson at about 57 GeV, resulting from an electromagnetic decay of the Z, with the accompanying photon consequently having an energy of 28 GeV. In the CMS case, the observed muon pairs are then thought to be produced by such 28 GeV photons.

Direct indications of this 57 GeV boson might be seen in small enhancements visible in diphoton invariant-mass distributions measured by CMS in 2013 and even in the above CMS dimuon data from 2018. Further evidence supporting a boson with a mass of about 57 GeV stems from a clear dip at about 115 GeV visible in diphoton data by CMS and ATLAS (both 2013), four-lepton signals by CMS and ATLAS (both 2013), and $\tau\tau$ as well as $\mu\mu$ invariant-mass distributions in $\ell^+\ell^-\gamma$ decays observed by L3 (2000). Such a dip is the inevitable manifestation of the onset of a threshold enhancement for the production of a pair of bosons, in any composite model of the vector gauge bosons and their (pseudo)scalar partners.

Session 3 / **52**

Doubly charged scalars' signal and low energy constraints

Author: Magdalena Kordiaczyńska[1]

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I will discuss doubly charged Higgs bosons $H^{\pm\pm}$ pair production in lepton and hadron colliders with their subsequent decays to four charged leptons. I will focus on the Higgs Triplet Model (HTM), which realizes Type-II seesaw mechanism, and Minimal Left-Right Symmetric Model (MLRSM). Both models contain extended scalar sector with additional triplet(s), leading to the existence of neutral and (singly and doubly) charged scalar particles. I discuss contribution of those
particles to the ρ-parameter, muon g-2, lepton flavor violation (LFV) processes and their connection to neutrino oscillations data within the HTM (normal and inverse mass hierarchies). Relations between LFV process, triplet vacuum expectation value (VEV) and possible collider lepton signals are analysed. MLRSM realizes the type I see saw mechanism with additional heavy neutrinos doubly charged particles interactions are not limited by light neutrino mass scenarios or oscillation parameters. I compare doubly charged scalar particles'
pair production at pp colliders within HTM and MLRSM, taking into account above connections.

Session 4 / **62**

New results on splitting functions in QCD at four- and five loops

Author: Sven-Olaf Moch[1]

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We report on recent progress on the splitting functions for the evolution of parton distributions and related quantities, the (lightlike) cusp anomalous dimensions, in perturbative QCD.
New results are presented for the four-loop (next-to-next-to-next-to-leading order, Nˆ3LO) contributions to the flavour-singlet splitting functions and the gluon cusp anomalous dimension.
We present first results, the moments N=2 and N=3, for the five-loop (Nˆ4LO) non-singlet splitting functions.

Session 4 / **81**

Perturbative Calculations for the Z-Penguin

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The so-called Z-Penguin is generated at one-loop order in the standard model and contributes to various flavour changing quark decays. I will discuss its phenomenology and its calculation in the standard model and beyond. A special focus will be put on the renormalisation of the Z-Penguin vertex in perturbative unitary theories.

Session 4 / **75**

Next-to-leading power corrections to Drell-Yan and prompt photon production

Author: Eric Laenen[1]

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I review recent progress in understanding the origin and structure of next-to-leading power threshold logarithms for prompt photon production and Drell-Yan, including, for the latter, their all order resummation at the leading logarithmic level.

Session 4 / **64**

On the μe-scattering at two loops

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In this talk I review the recent developments of the evaluation of the two-loop scattering amplitude μe —> μe. I focus my discussion on the implementation of the adaptive integrand decomposition algorithm and the interplay with available tools for the reduction and computation of multi-loop integrals. Furthermore, I comment on the progress made towards the renormalisation of the amplitude. Preliminary results are shown.

Outreach Session / **73**

O LHC do CERN - a máquina dos infinitos

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O LHC é o maior acelerador de partículas do mundo e, ao mesmo tempo, o nosso melhor "microscópio"para ver o mundo do infinitamente pequeno. Com ele, conseguimos já recriar o plasma que existiu logo após o Big Bang, e também descobrir o bosão de Higgs, a última partícula prevista pelo Modelo Padrão da física de partículas, que descreve o mundo subatómico.
Nesta palestra falaremos do que sabemos (e do que não sabemos!) sobre as partículas elementares, dos fantásticos instrumentos científicos que são o LHC e as suas experiências, e de como os usamos para aprender sobre o Universo.

Session 5 / **77**

Assessing the discovery potential of future high energy colliders: summary for WG3

Author: Janusz Gluza[1]

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I will summarize activity and results for objectives defined within the Working Group 3.

Session 5 / **45**

Are Higgs bosons talking to themselves?

Author: Gudrun Heinrich[1]

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While one of the parameters of the Higgs potential, the Higgs boson mass, is known quite well meanwhile, the Higgs boson self-couplings are still largely unconstrained.
We show how anomalous trilinear Higgs couplings, as well as other anomalous couplings in the Higgs sector, impact the shapes of distributions in Higgs boson pair production. In particular we investigate the interplay between higher order corrections within the Standard Model and BSM effects parametrized by Effective Field Theory.

Session 5 / **53**

Selected results in High Energy Factorization

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I would like to review recent progress in High Energy Factorization which aim at advancement of the formalism to account for large x effects as well as to account for proper operator definitions of parton densities.

Session 5 / **39**

The top quark mass parameter in Monte Carlo event generators

Author: Andre Hoang[1]

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I talk on the status on the theoretical interpretation of the top quark mass parameter in Monte Carlo event generators. This issue affects how the direct top quark mass measurements are related to field theory top quark mass measurements, and particular scrutiny has to be applied to theory and Monte Carlo event generators alike to match the experimental future prospects for direct mass measurements at the LHC. This field of research is just emerging and I explain subtleties and the tasks that lie ahead.

Session 6 / **78**

Generalisation of the Yang-Mills Theory and Physics Beyond the Standard Model

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We suggest an extension of the gauge principle which includes new tensor gauge bosons. In this extension of the Yang-Mills theory the vector bosons of SM become the members of the bigger family of gauge bosons of larger spins. The proposed extension is essentially based on the extension

of the Poincar´e algebra. We calculated the scattering amplitudes of tensor bosons at tree level, as well as their one-loop contribution into the Callan-Symanzik beta function. This contribution is negative and corresponds to the asymptotically free theory. The proposed extension leads to a natural inclusion of the Standard theory of fundamental forces into theory in which vector bosons, leptons and quarks represent a low-spin subgroup. We consider a possibility that inside the proton and, more generally, inside hadrons there are additional partons - tensorgluons, which can carry a part of the proton momentum. The parton distribution functions (PDF) of the tensorgluons is calculated. The extension of QCD influences the unification scale at which the coupling constants of the Standard Model merge, shifting its value to lower energies.

Session 6 / **51**

On the quark-gluon vertice

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We report on the quark-gluon vertice in the Landau gauge obtained via the combination of various non-perturbative methods. The vertex takes into account only its longitudinal tensor structures. The longitudinal form factors are strongly enhanced at the infrared region, deviate significantly from the tree level results for quark and gluon momentum below 2 GeV and at higher momentum approach their perturbative values. The computed quark-gluon vertex favours kinematical configurations where the quark momentum p and the gluon momentum q are small and parallel. Further, the quark-gluon vertex is dominated by the form factors associated to the tree level vertex γ_μ and to the operator $2\,p_\mu + q_\mu$. The higher rank tensor structures provide small contributions to the vertex.

Session 6 / **48**

Lattice computation of QCD propagators and vertices in Landau gauge

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In a Quantum Field Theory like QCD, the knowledge of all Green's functions allows a complete description of the theory. In particular, propagators of the fundamental fields of QCD (gluons, ghosts, quarks) encode information about non-perturbative phenomena like confinement or chiral symmetry breaking. In this talk we review recent results about these propagators and related vertices, computed with lattice QCD techniques in the Landau gauge.

Session 7 / **50**

An experimentalist's pursuit for the meaning of m_t and α_s

Author: Mikko Voutilainen[1]

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The top quark mass m_t and the strong coupling constant α_s are key parameters of the standard model, but they are only known to a precision of 0.3–1%. Together, their values determine the stability of the EW vacuum within the framework of the standard model (i.e. no new particles or fields), but even the meaning of their measured values is under debate: for top quark mass the difference between so-called MC mass and pole mass, for α_s the difference between lattice QCD measurements and the LEP/LHC measurements.

I will present some recent measurements from CMS on jet cross sections and kinematic top quark mass reconstruction. I will also discuss prospects for future measurements and ideas on constraining theoretical uncertainties from data, to better understand the meaning of m_t and α_s.

Session 7 / **76**

Jet studies at the CMS Experiment

Authors: Deniz Sunar Cerci[1]; Salim Cerci[1]

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In high energy processes, occur in proton-proton (pp) collisions at the LHC, partons (i.e. quarks and gluons) manifest themselves as hadronic jets. Jets are the perfect experimental tools that can be used to access the underlying partonic processes. The production of jets play a key role to test predictions of perturbative QCD (pQCD) over a wide region in phase space and constrains the parton distribution function (PDF) of the proton. The CMS Collaboration has performed many measurements of inclusive jet production at different centre-of-mass energies. In this talk the most recent jet results are presented.

Session 8 / **49**

α_s from jets in pp collisions

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Determination of the QCD coupling at NNLO accuracy

Session 8 / **80**

Probing CP violating top Yukawa in ttbar H channel

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The CP-nature of the top Yukawa may be probed in future runs of LHC, HL-LHC and HE-LHC. While this coupling is strongly constrained indirectly, there is strong motivation to access it directly in either tH or ttbar H channel in hadron colliders. To this end, we construct novel CP odd observables, discuss their sensitivity to CP violating top Yukawa, and discuss the interplay with CP-even observables in order to pin down the top Yukawa.

Session 8 / **56**

General Discussion / Brainstorming