Higgs and Effective Field Theory - HEFT 2024

Report of Contributions

Contribution ID: **5** Type: **not specified**

Froggatt-Nielsen Models Meet SMEFT

Thursday 13 June 2024 11:50 (10 minutes)

The Froggatt-Nielsen (FN) mechanism is one of the oldest and simplest attempts at explaining the striking hierarchies observed in the fermion masses and mixings. Given that FN models give rise to the correct fermion masses and mixings by construction and that the new particles predicted by the models are typically assumed to be heavy, it is not clear if the models are experimentally falsifiable. In this talk, we try to shed light on the question of falsifiability by analysing the infrared features of FN models whilst staying agnostic about the fine details of the model. We achieve our goal by writing down a FN effective field theory, capturing all the local interactions allowed in the ultraviolet, and matching it to the Standard Model effective field theory (SMEFT) at the tree- and 1-loop-level. Our results indicate a rich and non-trivial signature of FN models on the SMEFT Wilson coefficients, leaving us with falsifiable predictions that could be studied at current and future colliders.

Author: LOISA, Eetu

Presenter: LOISA, Eetu

Session Classification: Session

Contribution ID: **6** Type: **not specified**

On the convergence of the SMEFT expansion

Thursday 13 June 2024 18:15 (15 minutes)

I will discuss a forthcoming paper on the convergence of the SMEFT expansion in the specific case of Drell Yan. By using some top down examples I will show how realistic the use of data binned in energy to better constrain Wilson coefficients is, and when this approach fails. I will also explore when dimension-six squared terms improve the quality of (simplified) fits and when this approach leads to bad results.

Author: CORBETT, Tyler (University of Vienna)

Presenter: CORBETT, Tyler (University of Vienna)

Session Classification: Session

Contribution ID: **7** Type: **not specified**

Recent progress on Bosonic HEFT: renormalization, matching and colliders

Thursday 13 June 2024 16:50 (15 minutes)

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Some selected aspects of Bosonic HEFT with implications for multiple Higgs production at colliders will be presented. These include: 1) Recent progress on renormalization of 1PI functions and practical applications for specific processes at colliders, 2) The approach of matching UV theories to HEFT by identifying their predictions for amplitudes: the 2HDM case and its non-decoupling effects, 3) The search for sensitivities to Bosonic HEFT coefficients at colliders and the relevance of specific observables to explore potential correlations among those coefficients: the (kappaV, kappa2V) case.

Author: HERRERO SOLANS, Maria Jose (Universidad Autonoma de Madrid and IFT/UAM)

Presenter: HERRERO SOLANS, Maria Jose (Universidad Autonoma de Madrid and IFT/UAM)

Session Classification: Session

Contribution ID: **9** Type: **not specified**

Couplings of axion-like particles in linear and chiral EFT realisations

Wednesday 12 June 2024 17:40 (10 minutes)

Similarly to the difference between HEFT and SMEFT, a SM extension with an Axion-like Particle (ALP) can be parametrised in terms of a linear or chiral ALP-EFT, depending on whether the Higgs field is introduced as a doublet or a singlet, respectively.
In the linear case we particularly focus on the coupling of a light ALP to top quarks.
We use high-energy LHC probes and examine both the direct probe to this coupling in associated production of a top-pair with an ALP, and the indirect probe through loop-induced gluon fusion to an ALP leading to top pairs.
Using the latest LHC Run II data, we provide the best limit on this coupling and furthermore compare these limits with those obtained from loop-induced couplings in diboson final states.
In the chiral case, the EFT also contains tree-level couplings of an ALP to three bosons which give rise to the ALP-induced production of two Higgs bosons in association with a Z boson.
We examine the existing constraints from di-Higgs searches at Run 2 of the LHC and find that, despite the presence of extra objects in the final state, these searches are sensitive to ALP couplings.
Furthermore, we propose a dedicated search for HHZ states.
Finally, we compare the chiral EFT predictions with the contributions from top quark loops in the linear case.

Authors: Dr SALAS-BERNÁRDEZ, Alexandre (Universidad Complutense de Madrid); ESSER, Fabian; MADIGAN, Maeve (Heidelberg University); MADIGAN, Maeve Una; UBIALI, Maria (University of Cambridge (GB)); Prof. SANZ GONZALEZ, Veronica (Universities of Valencia and Sussex)

Presenter: ESSER, Fabian

Session Classification: Session

Contribution ID: **11** Type: **not specified**

The automation of SMEFT-assisted constraints on UV-complete models

Friday 14 June 2024 10:25 (15 minutes)

The ongoing Effective Field Theory (EFT) program at the LHC and elsewhere is motivated by streamlining the connection between experimental data and UV-complete scenarios of heavy new physics beyond the Standard Model (BSM). This connection is provided by matching relations mapping the Wilson coefficients of the EFT to the couplings and masses of UV-complete models. Building upon recent work on the automation of tree-level and one-loop matching in the SMEFT, we present a novel strategy automating the constraint-setting procedure on the parameter space of general heavy UV-models matched to dimension-six SMEFT operators. A new Mathematica package, match2fit, interfaces MatchMakerEFT, which derives the matching relations for a given UV model, and SMEFiT, which provides bounds on the Wilson coefficients by comparing with data. By means of this pipeline and using both tree-level and one-loop matching, we derive bounds on a wide range of single- and multi-particle extensions of the SM from a global dataset composed by LHC and LEP measurements. Whenever possible, we benchmark our results with existing studies. Our framework realises one of the main objectives of the EFT program in particle physics: deploying the SMEFT to bypass the need of directly comparing the predictions of heavy UV models with experimental data.
Additionally, thanks to upcoming work, this framework allows to easily obtain projected bounds on the same models from HL-LHC, FCC-ee or CEPC projections.
Based on arXiv:2309.04523 and upcoming work.

Author: ROSSIA, Alejo Nahuel (University of Manchester)

Co-authors: VRYONIDOU, Eleni (University of Manchester (GB)); MAGNI, Giacomo (Nikhef, VU Amsterdam); TER HOEVE, Jaco (Nikhef and VU Amsterdam); Dr ROJO, Juan (VU Amsterdam and Nikhef)

Presenter: ROSSIA, Alejo Nahuel (University of Manchester)

Session Classification: Session

Contribution ID: **13** Type: **not specified**

One-loop effective action up to dimension eight

Wednesday 12 June 2024 15:20 (15 minutes)

Indirect searches for new physics require precise measurements of low-energy observables. The EFT framework suitably accommodates the new physics contributions to such observables. As we aim for higher precision, it becomes necessary to incorporate higher-dimensional operators into our analysis as well. In this context, I will discuss the matching of UV theory with low energy theory up to dimension eight. A few years ago, the matching of UV theory to low energy theory was generalised, and a master formula known as Universal one-loop effective action (UOLEA) was developed and it was restricted to dimension six. We have used the method of Heat-Kernel to extend the UOLEA to incorporate dimension eight terms.

Author: Mr RAHAMAN, shakeel ur

Presenter: Mr RAHAMAN, shakeel ur

Session Classification: Session

Contribution ID: **16** Type: **not specified**

Impact of renormalisation group equation on Higgs production in the SMEFT

Thursday 13 June 2024 11:15 (10 minutes)

We study the impact of RGE running and mixing of SMEFT operators on differential observables in Hj, ttH and HH production at the LHC. We focus on a subset of operators closed under the QCD-induced anomalous dimension matrix and explore the impact of employing a fixed or dynamical scale on the EFT predictions for the Higgs transverse momentum and Higgs pair invariant mass spectra. We then explore the impact of taking into account RGE effects on the constraints obtained on the Wilson coefficients through fits to current data, as well as projections for the HL-LHC.

Author: VENTURA, Giuseppe

Co-authors: VRYONIDOU, Eleni (University of Manchester (GB)); Prof. MALTONI, Fabio (Universite Catholique de Louvain (UCL) (BE) and Università di Bologna)

Presenter: VENTURA, Giuseppe

Session Classification: Session

Contribution ID: **17** Type: **not specified**

Triboson production in the SMEFT

Wednesday 12 June 2024 10:25 (10 minutes)

The processes of triboson production in high-energy proton–proton collisions provide a unique mean to probe the quartic interactions between EW gauge bosons and to perform indirect searches for physics beyond the Standard Model. Despite their small cross-sections, the production of ⊠⊠⊠, ⊠⊠⊠, ⊠⊠⊠ (⊠ = ⊠ or ⊠) at centre-of-mass energy of 13 TeV at the LHC has recently been observed by the ATLAS and CMS experiments. In this talk I'll present a SMEFT analysis based on total rates and differential distributions of triboson processes and show that NLO QCD corrections have striking effects on dimension-6 operators.
I'll present constraints on a subset of SMEFT operators from a global EW fit including electroweak precision observables (EWPOs), diboson and triboson processes and show that, when quadratic EFT contributions are included, the diboson and triboson production at LHC can significantly improve the bounds in the directions left unconstrained by EWPOs.

Authors: VRYONIDOU, Eleni; CELADA, Eugenia; DURIEUX, Gauthier; MIMASU, Ken

Presenter: CELADA, Eugenia

Session Classification: Session

Contribution ID: **18** Type: **not specified**

Constraining new physics effective interactions via a global fit of electroweak, Higgs, top, and flavor observables

Friday 14 June 2024 09:30 (15 minutes)

We present results from a global fit of dimension-six SMEFT operators that includes electroweak, Higgs-boson, top-quark, and flavor observables. The leading-order scale dependence of the SMEFT Wilson coefficients is consistently included in the evolution from the UV scale to the electroweak scale and the low-energy scale of flavor observables. In defining the SMEFT set of active operators we consider both the $U(3)^5$ and the $U(2)^5$-symmetric limits. The global fit is obtained within the HEPfit framework and is based on the state-of-the-art of both experimental results and theoretical predictions for all the observables considered.

Authors: GONCALVES DOS SANTOS, Angelica; DE BLAS, Jorge (Universidad de Granada (ES)); REINA, Laura (Florida State University (US)); SILVESTRINI, Luca (INFN, Rome); VALLI, Mauro; MIRALLES, Victor (University of Manchester)

Presenter: MIRALLES, Victor (University of Manchester)

Session Classification: Session

Contribution ID: **19** Type: **not specified**

On γ_5 schemes and the interplay of SMEFT operators (in the Higgs-gluon coupling and beyond)

Wednesday 12 June 2024 12:45 (10 minutes)

We present a calculation of the four-top quark operator contributions to Higgs production via gluon fusion in the Standard Model Effective Field Theory. The four-top operators enter for the first time via two-loop diagrams. Due to their chiral structure they contain γ_5, so special care needs to be taken when using dimensional regularisation for the loop integrals. We use two different schemes for the continuation of γ_5 to D space-time dimensions in our calculations and present a mapping for the parameters in the two schemes. This generically leads to an interplay of different operators, such as four-top operators, chromomagnetic operators or Yukawa-type operators at the loop level. We validate our results by examples of matching onto UV models.

We also present recent developements towards a comprehensive map between NDR and BMHV at $\mathcal{O}\left(g_s^2\right)$ for all the operators in the Warsaw basis.

Authors: HEINRICH, Gudrun (KIT); LANG, Jannis; VITTI, Marco; GROEBER, Ramona (Università di Padova and INFN, Sezione di Padova); DI NOI, Stefano (Università di Padova and INFN, Sezione di Padova)

Presenter: DI NOI, Stefano (Università di Padova and INFN, Sezione di Padova)

Session Classification: Session

Contribution ID: **20** Type: **not specified**

Indirect constraints on top quark operators from a global SMEFT analysis

Wednesday 12 June 2024 17:25 (10 minutes)

In this talk I will focus on a model independent analysis of top-philic New Physics scenarios, under the assumption that only effective operators involving top quarks are generated at tree level. After an introduction on the SMEFT framework, I will illustrate the procedure we used to derive indirect constraints on Wilson Coefficients, combining a large set of observables: B and K decays, meson mixing observables, precision electroweak and Higgs measurements, anomalous magnetic moments, LFV processes, LFU tests and the Cabibbo anomaly. I will show the results through one-parameter, two-parameters and global fits, pointing out the interplay and the complementarity among the observables. I will also compare our results to direct bounds provided by top quark productions at LHC.

Authors: STANZIONE, Alfredo; RODRIGUEZ SANCHEZ, Antonio; MARZOCCA, David (INFN Trieste); GAROSI, Francesco

Presenter: STANZIONE, Alfredo

Session Classification: Session

Contribution ID: **21** Type: **not specified**

EFT observable stability under NLO corrections through interference revival

Wednesday 12 June 2024 10:10 (10 minutes)

The interference between the Standard Model (SM) and higher-dimensional effective operators can change sign over the phase space, leading to cancellations between different positive and negative terms that can make these effects hard to measure. The aim of this talk is to present a method to establish the efficiencies of given observables in separating the opposite-sign contributions to the interference, allowing to revive it in experiments. This strategy is based on the matrix element, but it is more general and can be used for any new physics scenario that shows a cancellation for the interference, in the Standard Model Effective Field Theory (SMEFT) and outside. I will show the application of this method to two dimension-six operators in the SMEFT, for which the interference suppression is well known: the anomalous gluon operator and its electroweak (EW) analogous, at Leading Order (LO) in the first case and at Next-to-Leading Order (NLO) in the second. Different processes that are sensitive to these objects will be analysed, including multi-jet, di-boson and EW Vector Boson Fusion (VBF) ones. I will highlight how the interference-reviving variables we found can yield better bounds on the operator coefficient, even at interference level.

Authors: DEGRANDE, Celine Catherine A; MALTONI, Matteo

Presenter: MALTONI, Matteo

Session Classification: Session

Contribution ID: **22** Type: **not specified**

EFT matching in spontaneously broken gauge theories

Wednesday 12 June 2024 15:00 (15 minutes)

There has been much progress in performing and understanding EFT matching at the one-loop order in the last decade; however, the methods have rarely been applied to the case of spontaneously broken gauge theories. In this talk, I reexamine the role of gauge symmetries in EFT matching. It is possible to prove the validity of the hard-region matching formula when using the background field (BF) gauge(s), in line with common thinking. In the case of spontaneously broken gauge theories, there are challenges to proceeding with the ordinary BF gauge, to the extent that it prevents a constructive proof. As an alternative, I will introduce a partially fixed BF gauge, which, in addition to being simpler than the ordinary BF gauge, allows for demonstrating the validity of the usual hard-region matching formula.

Author: Dr THOMSEN, Anders Eller (University of Bern)

Presenter: Dr THOMSEN, Anders Eller (University of Bern)

Session Classification: Session

Contribution ID: **23** Type: **not specified**

How to fit PDFs in the presence of new physics?

Friday 14 June 2024 09:50 (10 minutes)

The interpretation of hadron collider, such as the LHC, data, and the assessment of possible hints of new physics, require the precise knowledge of the proton structure in terms of parton distribution functions (PDFs). In this talk, I present a systematic methodology designed to determine whether and how global PDF fits might inadvertently 'fit away' signs of new physics, described by Effective Field Theory (EFT) corrections, in the high-energy tails of the distributions. I showcase a scenario for the High-Luminosity LHC, in which the PDFs may completely absorb such signs of new physics, thus biasing theoretical predictions and interpretations. I present strategies to single out the effects in this scenario and disentangle the inconsistencies that stem from them. A first solution I discuss is the exploration of the synergy between the high luminosity programme at the LHC and present and future low-energy measurements of large-sea quark distributions. A second one, is to fit simultaneously the PDFs and the new physics signals using the SMEFT framework, which can be done with our publicly released open-source tool SIMUnet.

Authors: HAMMOU, Elie (DAMTP, University of Cambridge); Dr MOORE, James (DAMTP, University of Cambridge); MANTANI, Luca (DAMTP, University of Cambridge); MADIGAN, Maeve (Heidelberg University); MORALES ALVARADO, Manuel; Prof. UBIALI, Maria (University of Cambridge (GB)); COSTANTINI, Mark; MANGANO, Michelangelo (CERN); KASSABOV-ZAHARIEVA, Z.D.

Presenter: HAMMOU, Elie (DAMTP, University of Cambridge)

Session Classification: Session

Contribution ID: **24** Type: **not specified**

Field redefinitions and infinite field anomalous dimension

Wednesday 12 June 2024 12:00 (10 minutes)

Field redefinitions are commonly used to remove redundant operators from the Lagrangian and thereby transform to a minimal operator basis. This is, for example, necessary when the theory has first been renormalized with off-shell kinematics in a larger basis. Working through an explicit example in the O(N) model, I will argue that such field redefinitions, while leaving the S-matrix invariant and finite, lead to infinite field anomalous dimensions γ_ϕ at two loops. These divergences cannot be removed by counterterms without reintroducing redundant operators.

Authors: MANOHAR, Aneesh; ROOSMALE NEPVEU, Jasper; PAGÈS, Julie

Presenter: ROOSMALE NEPVEU, Jasper

Session Classification: Session

Contribution ID: **25** Type: **not specified**

The LEFT at NLL accuracy

Wednesday 12 June 2024 12:15 (10 minutes)

Below the electroweak scale, the LEFT provides a systematic approximation of both heavy SM and BSM physics. When extending the LEFT to next-to-leading-log accuracy, a number of technical challenges arise. In this talk, I will discuss the basis construction in the 't Hooft-Veltman scheme, γ_5 and evanescent operators, the restoration of chiral symmetry, and the role of redundant operators in the cancellation of subdivergences.

Authors: NATEROP, Luca (University of Zürich and PSI); STOFFER, Peter

Presenter: NATEROP, Luca (University of Zürich and PSI)

Session Classification: Session

Contribution ID: **26** Type: **not specified**

Collider sensitivity to SMEFT heavy-quark operators at one-loop in top-quark processes

Wednesday 12 June 2024 17:05 (15 minutes)

We study the effects of four-heavy-quark operators in the production of top quarks in the framework of the Standard Model Effective Field Theory (SMEFT) at the LHC. In particular, we compute for the first time the total contribution of the four-top-quark operator which enters only at the one-loop level in the top-quark pair production process. Analytical results at one-loop are presented for the gluon- and quark-initiated sub-processes, which allowed a first complete validation of the SMEFT@NLO in Madgraph5_aMC@NLO. The 95% CL bounds on four-heavy-quark operators from the available top-quark pair and four-top-quark production data are provided, which are complementary to other bounds found in the literature. We focus on the comparison of the sensitivities of the top-quark pair and the four-top-quark production processes, where in the latter case the four-top-quark operator contributes at tree-level. We conclude that the sensitivities of the two processes to four-heavy-quark operators are comparable. The projected sensitivities of both processes at HL-LHC are also presented.

Authors: Dr VASQUEZ, Andres (University of Bonn); DEGRANDE, Celine Catherine A; ROSENFELD, Rogerio (Instituto de Física Teórica - UNESP & ICTP-SAIFR & LIneA)

Presenter: Dr VASQUEZ, Andres (University of Bonn)

Session Classification: Session

Contribution ID: **27** Type: **not specified**

Dimensionally reduced EFTs for cosmological phase transitions

Friday 14 June 2024 12:15 (10 minutes)

The upcoming launch of the LISA interferometer has recently strengthened the interest in exploring SM extensions where a gravitational wave-producing, strong first-order electroweak phase transition (SFOEWPT) occurs in the early universe. One of the preferred approaches to the study of thermal FOPTs is through the construction of a dimensionally reduced effective field theory (3dEFT) where the temperature only appears in the Wilson coefficients.

In this talk we will summarize the key aspects and advantages of this approach. We will provide a rigorous perturbative method to compute the essential observables for modelling the GW production in a SFOPT, and we will discuss the importance of including higher-order effective operators in these computations, which are often overlooked in the current literature.

Authors: LÓPEZ-MIRAS, Javier (Universidad de Granada); SANTIAGO, Jose (Universidad de Granada (ES)); CRIADO, Juan Carlos (University of Granada); GIL, Luis (Universidad de Granada); CHALA, Mikael (Universidad de Granada)

Presenter: GIL, Luis (Universidad de Granada)

Session Classification: Session

Contribution ID: **29** Type: **not specified**

Construction and conversion of operator bases in Effective Field Theories

Thursday 13 June 2024 09:30 (15 minutes)

The effective field theory is an important approach for systematically parameterizing new physics beyond the Standard Model. A central concern in effective field theory is constructing effective operator bases. This work focuses on studying operator bases in effective field theory. I will introduce a general method for constructing on-shell operator bases and off-shell Green's bases in Lorentz-invariant effective field theories. Furthermore, I will present the method for finding the conversion relations among operator bases.

Authors: Dr LI, Haolin (CP3/UCLouvain); Prof. YU, Jiang-Hao (nstitute of Theoretical Physics, Chinese Academy of Sciences); XIAO, Minglei; Dr ZHENG, Yu-Hui (School of Physics • Korea Institute for Advanced Study (KIAS)); REN, Zhe (The high-energy physics group (FTAE) of the University of Granada)

Presenter: REN, Zhe (The high-energy physics group (FTAE) of the University of Granada)

Session Classification: Session

Contribution ID: **30** Type: **not specified**

Missing Energy plus Jet in the SMEFT

Thursday 13 June 2024 12:35 (10 minutes)

The Standard Model Effective Field Theory serves as a widely utilized framework for exploring new physics (NP) effects in a model-independent manner.
In previous studies, Drell-Yan collider data has stood out as a promising signature due to its energy enhancement relative to Standard Model predictions.
In our investigation, we expand on this, by analyzing the "missing energy + jet" signature, which exhibits various forms of energy growth depending upon the operator type in play.
Overall we consider gluonic and electroweak dipole operators, semileptonic four-fermion operators and Z-penguin operators.
Constraints on gluon dipole operators are the strongest, probing NP scales up to $14\ \mathrm{TeV}$, and improve over existing ones from collider studies.
Additionally, our analysis of flavor-changing neutral current four-fermion operators has yielded competitive bounds compared to existing literature, and led to improvements for certain flavor combinations.

Authors: WENDLER, Daniel (TU Dortmund); HILLER, Gudrun (Technische Universitaet Dortmund (DE))

Presenter: WENDLER, Daniel (TU Dortmund)

Session Classification: Session

Contribution ID: **31** Type: **not specified**

Higgs boson offshell measurements probe non-linearity

Thursday 13 June 2024 17:25 (15 minutes)

The measurements of off-shell Higgs boson contributions in massive gauge boson pair production are known to probe its electroweak interactions across different energy scales. These are often employed as an estimator of the Higgs boson width in restricted theories of beyond the Standard Model physics. In this talk, I will revisit this measurement in the context of the Higgs Effective Field Theory (HEFT) framework and re-advertise its potential to probe the Higgs boson non-linearity. The relevant non-linear HEFT interactions are constrained by correlating the off-shell with the on-shell measurements. Thus, this so-called off-shell measurement complements related analyses of multi-Higgs final states.

Author: Dr ., Anisha (University of Glasgow)

Presenter: Dr ., Anisha (University of Glasgow)

Session Classification: Session

Contribution ID: **32** Type: **not specified**

Effective Field Theories of the MSSM

Thursday 13 June 2024 15:25 (15 minutes)

We match the Minimal Supersymmetric Standard Model (MSSM) onto its corresponding low-energy EFTs at one loop. For this purpose, we consider several scenarios: (i) matching the full MSSM onto SMEFT; (ii) integrating out only the lightest of the BSM states (such as the stops, sbottoms, gaugeinos, and Higgsinos), while neglecting the heavier states; (iii) integrating out only the heavy states, while retaining the lightest superpartners in the spectrum of the EFT. For these cases, we present the complete one-loop matching implementation in the Matchete code and discuss the challenges and subtleties involved in the calculation. Additionally, we examine some phenomenological implications and compare the different EFT scenarios.

Author: WILSCH, Felix (RWTH Aachen University)

Presenter: WILSCH, Felix (RWTH Aachen University)

Session Classification: Session

Contribution ID: **33** Type: **not specified**

New Physics virtual correction to top-pair production

Wednesday 12 June 2024 17:55 (10 minutes)

Being the heaviest fermion and having a Yukawa interaction almost equal to one, the top-quark represents one of the most interesting portals to New Physics (NP). If it is light or belongs to a secluded sector, NP can be difficult to detect in colliders with traditional methods. An alternative way, at least for setting bounds, is studying the virtual corrections to SM processes. Kinematical distributions of top-quark pairs produced at the LHC are studied both by the CMS and ATLAS experiments. A plethora of data for both the threshold region and the tails of the distributions are already available. In addition, SM theoretical predictions are known at very high accuracy (NNLO QCD and beyond). In this talk I will discuss the effect of virtual corrections to top-pair production coming from different types of NP: Axion-Like-Particles, CP-even and CP-odd scalars. I will also discuss the opportunity that top-pair production opens to bound new-particle interactions or probe their existence.

Authors: MARIOTTI, Alberto (VUB Brussels); PAGANI, Davide (Universita e INFN, Bologna (IT)); Prof. MALTONI, Fabio (Universite Catholique de Louvain (UCL) (BE) and Università di Bologna); MIMASU, Ken; BLASI, SIMONE (VUB - IDP (Vrije Universiteit Brussel)); TENTORI, Simone (UCLouvain)

Presenter: TENTORI, Simone (UCLouvain)

Session Classification: Session

Contribution ID: **34** Type: **not specified**

Triple-gauge couplings in LHC diboson production: a SMEFT view from every angle

Wednesday 12 June 2024 09:35 (15 minutes)

This study explores fully leptonic WZ and WW production within the SMEFT framework at NLO in QCD, focusing on both CP-even and CP-odd triple gauge coupling dimension-six operators. We investigate the off-shell production processes and contrast our findings with those derived under the narrow-width approximation. Alongside the conventional kinematical observables, we examine polarisation-related observables and angular coefficients. Moreover, we also assess potential SMEFT effects on asymmetry observables. Furthermore, through a sensitivity analysis, we identify critical LHC observables that are particularly sensitive to SMEFT-induced modifications, thereby shedding light on potential avenues for new physics searches in diboson production at the LHC.

Authors: VRYONIDOU, Eleni (University of Manchester (GB)); PELLICCIOLI, Giovanni (Max--Planck-Institut für Physik); EL FAHAM, Hesham (The University of Manchester)

Presenter: EL FAHAM, Hesham (The University of Manchester)

Session Classification: Session

Contribution ID: **36** Type: **not specified**

The SMEFT One Loop Dictionary

Wednesday 12 June 2024 15:40 (15 minutes)

Effective Field Theories provide an ordering criterion to classify all the possible new physics models, depending on the size of their contributions. At any fixed order in operator dimension and loop expansion, this classification can be organized in the form of UV/IR dictionaries, giving an efficient access to which operators are generated by a certain model and which models can generate a specific operator.

We present the complete classification of renormalizable extensions of the Standard Model with new scalars and fermions that can contribute to the dimension six SMEFT up to one loop. The results are encoded in a mathematica package called SOLD (SMEFT One Loop Dictionary), that provides extra functionalities to facilitate the calculation of the complete one-loop matching of any relevant model via Matchmakereft.

Authors: GUEDES, Guilherme (DESY); SANTIAGO, Jose (Universidad de Granada (ES)); OLGOSO, Pablo

Presenter: OLGOSO, Pablo

Session Classification: Session

Contribution ID: **37** Type: **not specified**

Methods for on-shell matching

Wednesday 12 June 2024 16:00 (10 minutes)

Effective field theories (EFTs) have become an essential tool in the search of new physics beyond the Standard Model. The calculation of the Wilson coefficients of the EFT for specific new physics models is usually performed by matching off-shell one-light-particle irreducible Green functions, which requires an off-shell basis of effective operators. This so-called Green's basis includes some operators that are redundant and can be written in terms of a minimal, physical basis when computing on-shell observables. This reduction is traditionally achieved by applying field redefinitions and equations of motion (EOMs). However, the absence of a systematic way of identifying the optimal field redefinition, coupled with the limitation that EOMs are only valid up to linear order in the perturbative expansion, calls for the search of a more systematic approach to the reduction of the Green's basis.

Our proposed method consists on performing a tree-level on-shell matching between the Green's and the physical bases. This matching requires a delicate cancellation between non-local contributions in both theories that we sidestep by evaluating the amplitudes with randomly generated physical momenta. Here, we present the application of this procedure to the dimension-eight Green's basis reduction of a toy model consisting on a real scalar field with $\mathbb{Z}_2$ symmetry. Furthermore, we derive the reduction of a large set of operators in the SMEFT as well as some examples of renormalization group equations.

Authors: Ms VILCHES BRAVO, Fuensanta (Universidad de Granada); LÓPEZ MIRAS, JAVIER; SANTIAGO, Jose (Universidad de Granada (ES)); CHALA, Mikael (Universidad de Granada)

Presenter: LÓPEZ MIRAS, JAVIER

Session Classification: Session

Contribution ID: **38** Type: **not specified**

CP violation in gluon-induced diboson processes

Wednesday 12 June 2024 09:55 (10 minutes)

The existence of CP violation is key to address the mystery of matter-antimatter asymmetry in the Universe. As the amount of CP violation in the SM is insufficient, the search for new sources of CP violation is of high priority for the LHC programme. We study CP violation within the Standard Model Effective Field Theory, focusing on the impact of CP-odd dimension-6 operators in gluon-induced diboson production. We start by extending the SMEFTatNLO implementation to include the relevant operators and study double Higgs, double Z/W, and associated ZH and H+jet production. In addition we compute analytically the helicity amplitudes of the aforementioned processes at one loop and with one insertion of a CP-odd operator. We analyse the impact of CP-even and CP-odd operators on kinematic distributions of key observables in these processes. We identify certain observables that can lead to powerful probes of these operators and discrimination between CP-even and CP-odd interactions at the HL-LHC.

Authors: VRYONIDOU, Eleni (University of Manchester (GB)); THOMAS, Marion; MIRALLES, Victor (University of Manchester)

Presenter: THOMAS, Marion

Session Classification: Session

Contribution ID: **39** Type: **not specified**

The Standard Model Gauge Group, SMEFT, and Generalized Symmetries

Thursday 13 June 2024 15:05 (15 minutes)

We discuss heavy particles that can be used to pin down the faithful Standard Model (SM) gauge group and their patterns in the SM effective field theory (SMEFT). These heavy particles are not invariant under a specific $\mathbb{Z}_6$ subgroup of $SU(3)_c \times SU(2)_L \times U(1)_Y$, which however acts trivially on all the SM particles, hence the faithful SM gauge group remains undetermined. Different realizations of the faithful SM gauge group correspond to different spectra of heavy particles, and they also correspond to distinct sets of line operators with one-form global symmetry acting on them. We show that the heavy particles not invariant under the $\mathbb{Z}_6$ group cannot appear in tree-level ultraviolet completions of SMEFT, this enforces us to consider one-loop UV completions of SMEFT to identify the $\mathbb{Z}_6$ non-invariant heavy particles. We demonstrate with examples that correlations between Wilson coefficients provide an efficient way to examine models with $\mathbb{Z}_6$ non-invariant heavy particles. Finally, we prove that all the scalars that can trigger electroweak symmetry breaking must be invariant under the $\mathbb{Z}_6$ group, hence they cannot be used to probe the faithful SM gauge group.

Authors: LI, Hao-Lin; XU, Ling-Xiao (ICTP, Trieste)

Presenter: XU, Ling-Xiao (ICTP, Trieste)

Session Classification: Session

Contribution ID: **40** Type: **not specified**

Jet Bundle Geometry of Scalar EFTs

Thursday 13 June 2024 16:05 (10 minutes)

Geometric formulations of scalar field theories have proven valuable in studying the differences between HEFT and SMEFT at the two derivative level by representing fields as coordinates on a 4D manifold and expressing field redefinitions as coordinate transformations.
We introduce an approach to extend the geometric formulation to higher numbers of derivatives as well as incorporating the potential into a geometric definition by introducing jet bundles where derivatives of fields are treated as independent coordinates on higher-dimensional manifolds.
The talk will introduce the formalism of bundles showing how a Lagrangian can be expressed geometrically as well as how amplitudes can be constructed from geometric quantities.

Authors: BRIVIO, Ilaria (University & INFN Bologna); DAVIGHI, Joseph Enea; ALMINAWI, Mohammad

Presenter: ALMINAWI, Mohammad

Session Classification: Session

Contribution ID: **41** Type: **not specified**

Heavy Dark Matter EFT for any spin

Thursday 13 June 2024 10:10 (15 minutes)

We construct an effective field theory for non-relativistic heavy dark matter of arbitrary spin based on the Little group formalism. We present the most general HDMEFT basis up to dimension seven and show that it reproduces the non-relativistic spin 1/2 case presented in the literature. We also discuss the matching onto the relativistic DM EFT.

Authors: Dr STAMOU, Emmanuel (TU Dortmund); BISHARA, Fady Adibsamy (DESY); BROD, Joachim (University of Cincinnati); ZUPAN, Jure (University of Cincinnati); KVEDARAITE, Sandra (University of Granada)

Presenter: KVEDARAITE, Sandra (University of Granada)

Session Classification: Session

Contribution ID: **42** Type: **not specified**

Loop-corrected Fierz Identities and Evanescent shifts

Wednesday 12 June 2024 12:30 (10 minutes)

In Effective Field Theories, evanescent operators are introduced to compensate for the breakdown of four-dimensional Dirac identities (e.g. Fierz Identities) when used in combination with dimensional regularization.

In this talk, we provide an alternative approach where contributions of evanescent operators are viewed as corrections to d=4 Dirac relations. This new perspective not only simplifies computations but provides a clearer understanding of the treatment of these evanescent contributions in the context of NLO change of operator bases.

Author: PESUT, Marko (University of Zürich)

Presenter: PESUT, Marko (University of Zürich)

Session Classification: Session

Contribution ID: **43** Type: **not specified**

Precision tests of third-generation four-quark SMEFT operators

Wednesday 12 June 2024 16:45 (15 minutes)

In the framework of the SMEFT we derive the indirect constraints on third-generation four-quark operators that arise from electroweak precision measurements as well as flavour physics. To this purpose we calculate the dominant one- and two-loop contributions to the observables in question. We find that the considered loop effects can lead to better constraints than those from fits to top-quark data collected at the LHC.

Authors: SCHNELL, Luc (Max Planck Institute for Physics); HAISCH, Uli (MPI Munich)

Presenter: HAISCH, Uli (MPI Munich)

Session Classification: Session

Contribution ID: **45** Type: **not specified**

The running of Higgs decays at dimension eight in the SMEFT

Wednesday 12 June 2024 11:40 (15 minutes)

Higgs decays to gg, $\gamma\gamma$ and γZ are important physical processes for Higgs physics with the latter having been recently observed at ATLAS and CMS; all of these decays arise at loop-level in the SM. Under the assumption of weakly coupled, renormalizable UV scenarios, the SMEFT can also only receive matching contributions to these processes at loop-level at dimension-6. Furthermore, study of the renormalization group equations shows that no tree-level generated operators can induce the running of these decays.
However, considering the arguments which explain the renormalization structure and perturbative origin of the operators at dimension-six, the dimension-eight operators responsible for Higgs decays seem to have a richer structure, namely possibly being tree-level generated and receiving renormalization contributions from other tree operators. In this talk we will go over the dimension-eight parameterization of these Higgs decays and verify that the linear combination of Wilson coefficients contributing to these processes does vanish at tree-level as expected. We also verify that, unlike at dimension-six, trees can mix into loops in the running of $h \to \gamma Z$, an effect only captured when considering the dimension-eight SMEFT. This structure points to better basis choice to describe these processes. We will also show that this effect is not only new qualitatively but it can also be observed at future experiments for some scenarios.

Author: GUEDES, Guilherme (DESY)

Co-authors: GROJEAN, Christophe; SALLA, Gabriel; NEPVEU, Jasper

Presenter: GUEDES, Guilherme (DESY)

Session Classification: Session

Contribution ID: **46** Type: **not specified**

Anomalous Dimensions via on-shell Methods: Operator Mixing and Leading Mass Effects

Thursday 13 June 2024 10:30 (10 minutes)

We elaborate on the application of on-shell and unitarity-based methods for evaluating renormalization group coefficients, and generalize this framework to account for the mixing of operators with different dimensions and leading mass effects. We derive a master formula for anomalous dimensions stemming from the general structure of operator mixings, up to two-loop order, and show how the Higgs low-energy theorem can be exploited to include leading mass effects. A few applications on the renormalization properties of popular effective field theories showcase the strength of the proposed approach, which drastically reduces the complexity of standard loop calculations. Our results provide a powerful tool to interpret experimental measurements of low-energy observables, such as flavor violating processes or electric and magnetic dipole moments, as induced by new physics emerging above the electroweak scale.

Authors: LEVATI, Gabriele (Università degli studi di Padova and INFN Padova); BRESCIANI, Luigi Carlo (University & INFN Padova); Prof. PARADISI, Paride (University of Padova and INFN); MASTROLIA, Pierpaolo (Universita e INFN, Padova (IT))

Presenter: BRESCIANI, Luigi Carlo (University & INFN Padova)

Session Classification: Session

Contribution ID: **47** Type: **not specified**

The global flavour structure of the LEFT

Thursday 13 June 2024 11:30 (15 minutes)

Below the electroweak scale, the gauge interactions of QED and QCD are responsible for the running of the many effective operators of the LEFT (aka WET). As these gauge interactions also preserve both parity and flavour to all orders, decomposing the operators according to their parity and many flavour charges vastly simplifies their running.

Such a decomposition makes the one-loop running of a generic LEFT, from the W mass down to the b mass, semi-analytically soluble. I will show how this gives a more global picture of how flavour phenomenology below the electroweak scale matches on to that above it, using a case study of operators relevant for semi-leptonic B decays.

Authors: Mr SMITH, Ben (University of Glasgow); SUTHERLAND, David; RENNER, Sophie Alice (University of Glasgow (GB))

Presenter: SUTHERLAND, David

Session Classification: Session

Contribution ID: **48** Type: **not specified**

EFT tools to probe CP-violating axion-like particles

Thursday 13 June 2024 14:50 (10 minutes)

CP-violating probes are among the most promising and yet relatively unexplored ways to look for Axion-like particles (ALPs) and to investigate their phenomenology.
Starting from the most general dimension-5, $SU(3)_c \times U(1)_{em}$ invariant effective Lagrangian for a CP-violating ALP at the electroweak (EW) scale, we discuss two relevant phenomenological frameworks.
In the first one, the impact of heavy ALPs ($m_a \gg 1$ GeV) on low-energy CP-violating observables is analyzed in detail.
In the second one we rather consider lighter ALPs ($m_a \ll 1$ GeV). In this case, QCD can no longer be treated perturbatively and the CPV interactions of ALPs are included in a chiral perturbation theory setup.
Given the resemblance between our setup and the HEFT one, where the Higgs field is treated as a singlet, parallels between the two scenarios are drawn.

Author: LEVATI, Gabriele (Università degli studi di Padova and INFN Padova)

Presenter: LEVATI, Gabriele (Università degli studi di Padova and INFN Padova)

Session Classification: Session

Contribution ID: **50** Type: **not specified**

Exploring ALP EFTs: Operator Basis Construction and Hilbert Series Techniques

Thursday 13 June 2024 09:50 (15 minutes)

Axions and axion-like particles (ALPs) hold promise in addressing fundamental puzzles in physics. In this talk, we use effective field theories (EFTs) to investigate the intricate interactions between ALPs and Standard Model particles across various energy scales. Employing Hilbert series techniques, we unveil the underlying structure of these interactions, distinguishing between those that preserve or break shift symmetry. Our analysis extends to computing the Hilbert series and constructing operator bases up to dimension 8 for both aSMEFT and aLEFT. Additionally, we use the Hilbert series method to enumerate sources of CP violation in terms of CP-even, CP-odd, and CP-violating operators. Complementing theoretical insights, we introduce a Mathematica package for Hilbert series computations. This package is designed to address general problems, allowing people to use it for a wide range of applications beyond the scope of ALP EFTs.

Authors: GROJEAN, Christophe (DESY (Hamburg), Humboldt University (Berlin) and CERN); KLEY, Jonathan (DESY); YAO, Chang-Yuan

Presenter: YAO, Chang-Yuan

Session Classification: Session

Contribution ID: **51** Type: **not specified**

Small Instanton-induced Flavor Invariants and the Axion Potential

Thursday 13 June 2024 14:30 (15 minutes)

Small instantons which increase the axion mass due to an appropriate modification of QCD at a high energy scale, can also enhance the effect of CP-violating operators to shift the axion potential minimum by an amount $\theta_{\rm ind}$, which is severely constrained by neutron electric dipole moment experiments. In this talk, focusing on the dimension-six CP-odd operators in the Standard Model Effective Field Theory (SMEFT), we will introduce a new set of determinant-like flavor invariants that naturally arise in the instanton computation of the quantity $\theta_{\rm ind}$. We will show that these flavor invariants are useful for anticipating how CP-violating SMEFT operators participate in the instanton computations and for classifying the leading effects from the Wilson coefficients. More generally, the flavor invariants, together with an instanton Naive Dimensional Analysis, can be used to more accurately estimate small instanton effects in the axion potential that arise from any SMEFT operator and to conveniently probe the impact of different flavor assumptions on the bounds obtained from $\theta_{\rm ind}$.
Eventually, we will present our recent development on the shift-breaking interactions between axions and SM particles generated by small instanton dynamics.

Reference: arXiv: 2402.09361 (https://arxiv.org/abs/2402.09361)

Authors: GROJEAN, Christophe (DESY (Hamburg), Humboldt University (Berlin) and CERN); GUEDES, Guilherme (DESY); VUONG, Hoa (DESY); KLEY, Jonathan (DESY); BEDI, Ravneet Singh (University of Minnesota); GHERGHETTA, Tony (University of Minnesota (US))

Presenter: VUONG, Hoa (DESY)

Session Classification: Session

Contribution ID: **52** Type: **not specified**

A Geometrical Formalism of Functional Matching

Thursday 13 June 2024 15:45 (15 minutes)

Field space geometry has been fruitful in understanding many aspects of EFT, including basis-independent criteria for distinguishing HEFT vs. SMEFT, reorganization of scattering amplitudes in covariant form, derivation of renormalization group equations and geometric soft theorem. We incorporate field space geometry in functional matching by dividing the field space into light and heavy subspaces. A modified covariant derivative expansion method is proposed to calculate the functional traces while accommodating the covariance of the light subspace geometry. We apply this formalism to the non-linear sigma model and reproduce the effective theory more efficiently compared to other matching methods.

Author: LI, Xu-Xiang (University of Utah)

Co-authors: LU, Xiaochuan (University of California, San Diego); ZHANG, Zhengkang (University of Utah)

Presenter: LI, Xu-Xiang (University of Utah)

Session Classification: Session

Contribution ID: **53** Type: **not specified**

Loop effects on Higgs and vector boson production in HEFT

Thursday 13 June 2024 17:10 (10 minutes)

The absence of newly discovered states at high energies makes the use of Effective Field Theories (EFTs) the adequate tool to describe the electroweak sector. Within the available EFTs, the Higgs Effective Field Theory (HEFT) provides the most general parametrization of electroweak physics. In this context, effects of new physics can substantially modify the lowest-order couplings of HEFT and produce large effects on observables that can be directly tied to ultraviolet models. We will consider the effect of one-loop contributions to the production of vector bosons and the Higgs in HEFT and study the impact of possible new physics on these processes.

Author: Mr QUEZADA CALONGE, Carlos (Universidad Complutense de Madrid)

Presenter: Mr QUEZADA CALONGE, Carlos (Universidad Complutense de Madrid)

Session Classification: Session

Contribution ID: **54** Type: **not specified**

smelli 3 - a flavourful global SMEFT likelihood

Friday 14 June 2024 10:05 (15 minutes)

We report on a new major version of the Python package **smelli** - the SMEFT likelihood, which implements a flavourful global likelihood function for the Standard Model Effective Field Theory (SMEFT), the Weak Effective Theory (WET), and new physics models. No specific flavour structure is assumed and the renormalization group evolution in the SMEFT and the WET is taken into account to consistently combine a large number of observables at many different scales, including electroweak precision observables, Higgs physics, decays of B mesons, kaons, D mesons, muon, and tau, meson mixing observables, lepton flavour violating decays, neutron and nuclear beta decays, and high-mass Drell-Yan tails. Besides the addition of many observables, new features include the new physics dependence of theory uncertainties and a three order of magnitude increase in evaluation speed.

Author: STANGL, Peter (CERN)

Presenter: STANGL, Peter (CERN)

Session Classification: Session

Contribution ID: **57** Type: **not specified**

Why use SMEFT?

Wednesday 12 June 2024 09:05 (20 minutes)

Author: DAWSON, Sally (BNL)

Presenter: DAWSON, Sally (BNL)

Session Classification: Session

Contribution ID: **58** Type: **not specified**

Recent developments in EFT scattering amplitudes and positivity constraints

Thursday 13 June 2024 09:00 (20 minutes)

Author: SHEN, Chia-Hsien (National Taiwan University)

Presenter: SHEN, Chia-Hsien (National Taiwan University)

Session Classification: Session

Contribution ID: **59** Type: **not specified**

Precision calculation in SMEFT

Wednesday 12 June 2024 11:10 (20 minutes)

Author: PECJAK, Ben (IPPP Durham)

Presenter: PECJAK, Ben (IPPP Durham)

Session Classification: Session

Contribution ID: **60** Type: **not specified**

Recent developments in the EFT matching and RG running.

Wednesday 12 June 2024 14:30 (20 minutes)

Author: FUENTES-MARTIN, Javier (Universidad de Granada)

Presenter: FUENTES-MARTIN, Javier (Universidad de Granada)

Session Classification: Session

Contribution ID: **61** Type: **not specified**

Global analyses and the role of Machine Learning in EFT searches.

Friday 14 June 2024 09:00 (20 minutes)

Author: Prof. SANZ GONZALEZ, Veronica (Universities of Valencia and Sussex)

Presenter: Prof. SANZ GONZALEZ, Veronica (Universities of Valencia and Sussex)

Session Classification: Session

Contribution ID: **62** Type: **not specified**

SMEFT effects in neutrino and low-energy experiments

Thursday 13 June 2024 12:05 (20 minutes)

Author: FALKOWSKI, Adam (LPT Orsay)

Presenter: FALKOWSKI, Adam (LPT Orsay)

Session Classification: Session

Contribution ID: **63** Type: **not specified**

Recent developments of dimension 8 effects in SMEFT

Thursday 13 June 2024 17:45 (20 minutes)

Author: FONTES, Duarte

Presenter: FONTES, Duarte

Session Classification: Session

Contribution ID: **64** Type: **not specified**

EFT of large scale structures in cosmology

Friday 14 June 2024 11:15 (20 minutes)

Author: SIMONOVIC, Marko (CERN)

Presenter: SIMONOVIC, Marko (CERN)

Session Classification: Session

Contribution ID: **65** Type: **not specified**

Physics opportunities at future lepton colliders

Friday 14 June 2024 12:30 (20 minutes)

Author: BUTTAZZO, Dario

Presenter: BUTTAZZO, Dario

Session Classification: Session

Contribution ID: **66** Type: **not specified**

EFTs for finite temperature

Friday 14 June 2024 11:45 (20 minutes)

Author: CHALA, Mikael (Universidad de Granada)

Presenter: CHALA, Mikael (Universidad de Granada)

Session Classification: Session

Contribution ID: **67** Type: **not specified**

Welcome

Wednesday 12 June 2024 09:00 (5 minutes)

Session Classification: Session

Contribution ID: **68** Type: **not specified**

Closing

Friday 14 June 2024 13:00 (5 minutes)

Session Classification: Session