International Meeting on EFFECTIVE PATHWAYS TO NEW PHYSICS (IMEPNP)

Monday 7 February 2022 - Saturday 12 February 2022

Institute of Physics, Bhubaneswar

Book of Abstracts

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Consequences of $b \to s\,\mu^+\,\mu^-$ anomalies on $B \to K^{(*)}\,\nu\,\bar{\nu}$, $B_s \to (\eta, \eta')\,\nu\,\bar{\nu}$ and $B_s \to \phi\,\nu\,\bar{\nu}$ decay observables

Authors: Rajeev N[None]; Rupak Dutta[1]

[1] *University of Kentucky*

The long persistent discrepancies in $b \to s\,\ell\,\ell$ quark level transitions continue to be the ideal platform for an indirect search of new physics that lies beyond the standard model. The recent updated measurements of R_K, $\mathcal{B}(B_s \to \phi\,\mu^+\,\mu^-)$ and $\mathcal{B}(B_s \to \mu^+\,\mu^-)$ from LHCb persistently deviate from the standard model expectations at the level of 3.1σ in R_K and 3.6σ in $\mathcal{B}(B_s \to \phi\,\mu^+\,\mu^-)$. Similarly, the measurements of R_{K^*} and P_5' in $B \to K^*\,\ell\,\ell$ decays still continue to disagree with the standard model at $\sim 2.4\sigma$ and $\sim 3.3\sigma$ respectively. Similarly the new tests of lepton flavor universality performed using the isospin partners such as $B^0 \to K_S^0\,\ell\,\ell$ and $B^+ \to K^{+*}\,\ell\,\ell$ exhibit the same pattern of deviation with the previous results. The new ratios $R_{K_S^0}$ and $R_{K^{*+}}$ stand respectively at 1.4σ and 1.5σ away and the combination of both stand at 2σ away from the standard model expectations. Motivated by these

anomalies we search for the patterns of new physics
in the family of flavor changing neutral decays with neutral leptons in the final state undergoing $b \to s\,\nu\,\bar{\nu}$ quark level transitions.
There are close relations in the analysis of $b \to s\,\ell\,\ell$ and $b \to s\,\nu\,\bar{\nu}$ transitions not only in standard model but also in
various beyond the standard model scenarios. For beyond the standard model physics under the $\mathrm{SU_L}(2)$ gauge symmetry one can relate the left handed charged leptons
to the neutrinos. Moreover, there are several advantages of studying $b \to s\,\nu\,\bar{\nu}$ transitions over $b \to s\,\ell\,\ell$ as they are
free from various hadronic uncertainties beyond the form factors such as the non-factorizable corrections and photonic penguin contributions.
Hence, we explore the consequences of $b \to s\,\mu^+\,\mu^-$ anomalies on $B \to K^{(*)}\,\nu\,\bar{\nu}$,
$B_s \to (\eta, \eta')\,\nu\,\bar{\nu}$ and $B_s \to \phi\,\nu\,\bar{\nu}$ decay observables in SMEFT platform within various 1D and 2D new physics
scenarios.

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An EFT Compendium for Exploring BSM

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Right Handed Neutrinos, TeV Scale BSM Neutral Higgs and FIMP Dark Matter in EFT Framework

Author: ROJALIN PADHAN[1]

Co-authors: Genevieve Belanger [2]; Manimala Mitra ; Sarif Khan ; SUJAY SHIL [3]

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We consider an effective field theory framework with three standard model (SM) gauge singlet right handed neutrinos, and an additional SM gauge singlet scalar field. The framework successfully generates eV masses of the light neutrinos via seesaw mechanism, and accommodates a feebly interacting massive particle (FIMP) as dark matter candidate. Two of the gauge singlet neutrinos participate in neutrino mass generation, while the third gauge singlet neutrino is a FIMP dark matter. We explore the correlation between the vev of the gauge singlet scalar field which translates as mass of the BSM Higgs, and the mass of dark matter, which arises due to relic density constraint. We furthermore explore the constraints from the light neutrino masses in this set-up. We chose the gauge singlet BSM Higgs in this framework in the TeV scale. We perform a detailed collider analysis to analyse the discovery prospect of the TeV scale BSM Higgs through its di-fatjet signature, at a future pp collider which can operate with $\sqrt{s} = 100$ TeV c.m.energy.

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Higgs Self-coupling in EFT framework

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Constraining the SMEFT top sector via searches in tZj and $t\bar{t}Z$ channels with Machine Learning

Authors: Rahool Kumar Barman[1]; Ahmed Ismail[None]

[1] *Oklahoma State University*

We explore the projected sensitivity for SMEFT coefficients $\mathcal{C}_{tZ}$ and $\mathcal{C}_{tW}$ via single top $pp \to tZj$ and top pair associated production $pp \to t\bar{t}Z$ channels with machine learning techniques, at the high luminosity LHC. Implications from new physics modifications in relevant background processes are also included. We identify the subset of observables that are most relevant towards constraining $\mathcal{C}_{tZ}$ and $\mathcal{C}_{tW}$.

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Light from the Neutrinos and Pathways to New Physics

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Dark Matter freeze-in and freeze-out via Effective Operators: A couple of illustrations

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Consequences of □→□□+□– anomalies on □→□(∗)□□−, □□→(□,□′)□□− and □□→□□□□− decay observables

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Right Handed Neutrinos, TeV Scale BSM Neutral Higgs and FIMP Dark Matter in EFT Framework

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Searching for New Physics with the Standard Model Effective Field Theory

Monday Afternoon Session / 45

Inauguration by Director, IOP

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Cancellation in Dark Matter-Nucleon Interactions: the Role of Non-Standard-Model-like Yukawa Couplings

Authors: Bibhabasu De[1]; Debottam Das[2]; Subhadip Mitra[3]

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[3] *IIIT Hyderabad*

Extensive searches to probe the particle nature of dark matter (DM) have been going on for some decades now but, so far, no conclusive evidence has been found. Among various options, the Weakly Interacting Massive Particles (WIMP) remains one of the prime
possibilities as candidates for DM near the TeV scale. Taking a phenomenological view, such null results may be explained for a generic WIMP in a Higgs-portal scenario if we allow the light-quark Yukawa couplings to assume non-Standard Model (non-SM)-like values. This follows from a cancellation among different terms in the DM-nucleon scattering which can, in turn, lead to a vanishingly small direct-detection cross section. It might also lead to isospin violation in the DM-nucleon scattering. Such non-SM values of light-quark Yukawa couplings may be probed in the high luminosity run of the LHC.

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Phenomenological analysis of the effective extensions of BSM scenarios

Authors: Anisha .[1]; Christoph Englert[2]; Joydeep Chakrabortty[1]; Panagiotis Stylianou[2]; Upalaparna Banerjee[1]; Michael Spannowsky[3]

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The spectrum of the new physics beyond the Standard Model is very likely to be non-degenerate with few light non-SM particles residing close to the electroweak scale. The effect of the more complete theory then can be captured through an effective extension of the BSM scenario treating the new non-SM particles on the same footing along with the SM ones. To perform a detailed phenomenological analysis of such cases, one needs to be familiar with the proper structures of the higher dimensional operators constituted of the SM degrees of freedoms and the minimal extension. We consider two different scalar extensions of the SM and their effective field-theoretic generalisations.

We demonstrate the method to construct the gauge-invariant forms of the effective operators and present the operator
structures for these two cases. We also investigate their impacts on the low-energy observables, such as precision measurements of the anomalous magnetic
moment of the muon, precision Higgs measurements, and direct collider sensitivity to charged Higgs searches.

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Automatisation of Integrating out heavy fields at one-loop

Author: shakeel ur rahaman[None]

The success of the Standard Model (SM) and the lack of direct evidence of any beyond Standard Model (BSM) particles impels us to look for indirect shreds of evidence. The effective field theory framework is just the right tool for that. We can treat the SM as an effective theory by adding higher dimensional terms to its Lagrangian and trying to capture the footprint of the more complete UV theory, this is commonly known as the bottom-up approach. On the other hand, we can choose a complete UV theory, identify the heavy degrees of freedom, integrate them out and obtain operators of higher mass dimension, known as the top-down approach. Covariant Derivative Expansion (CDE) is one of the methodologies that integrate out heavy fields and generate the effective operator and their Wilson coefficient. The two most intriguing traits of CDE are, firstly, the method is manifestly gauge-invariant so the effective operators generated at the end are also gauge-invariant. Secondly, its applicability is universal. Encapsulating these features there is a formula dubbed as the universal one-loop effective action (UOLEA) which has algorithmic essence to it. The Mathematica based package CoDEx based on the UOLEA is one of the tools that can integrate out heavy particles from the tree as well as one-loop diagrams and generate effective operators of mass dimension-6. It provides the operators in two different bases: "Warsaw" and "SILH" and can perform the renormalisation group evolutions (RGE) of operators to some low energy scales.

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EFT Diagrammatica: UV roots of the CP-conserving SMEFT

Author: Suraj Prakash[None]

The Standard Model Effective Field Theory (SMEFT) is an established theoretical framework that parametrizes the impact of UV models on low-energy observables. Such parametrization is achieved by studying the interactions of SM fields encapsulated within higher mass dimensional (≥ 5) operators. Through judicious employment of the EFT toolkit, SMEFT has become a source of new predictions as well as a platform for conducting a coherent comparison of new physics (beyond Standard Model) scenarios. In this talk, I will elucidate a diagrammatic approach to establish selection criteria for the allowed heavy field representations corresponding to a subset of the dimension-6 SMEFT operator basis. The contact interactions representing each effective operator can be unfolded into tree- and (or) one-loop-level diagrams to reveal unique embeddings of heavy field propagators within them. The unfolding of operators can be accomplished based solely on symmetry arguments. The interrelation between SMEFT operators and observables has been well documented in recent years. Our diagrammatic procedure enables us to catalogue heavy field representations for each SMEFT operator, thereby building well-defined links between different sets of observables and families of UV models. This makes it convenient to test the viability of the models involving these heavy fields. This also prevents redundant analyses of similar models.

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Directly Probing the Higgs-top Coupling at High Scales

Author: Roshan Mammen Abraham[1]

[1] *Oklahoma State University*

The top-quark Yukawa coupling, y_t is the strongest interaction of the Higgs boson in the Standard Model (SM) with y_t~1. Due to its magnitude, it plays a central role in Higgs phenomenology in the SM and would be most sensitive to physics beyond the Standard Model. The top Yukawa can be directly measured at the LHC via top pair production in association with a Higgs boson, $t\bar{t}h$ channel. We study new physics effects for the Higgs-top coupling at high scales, using jet substructure techniques. We present the high-luminosity LHC sensitivity to new physics parametrized in the EFT framework and through a general Higgs-top form factor.

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Directly Probing the Higgs-top Coupling at High Scales

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Measurement of Higgs self coupling from non-resonant Higgs pair production in CMS experiment

Author: Soumya Mukherjee[1]

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The trilinear self-coupling (λ) of Higgs can directly be accessed at the LHC by inclusive production of Higgs boson pair. A search for the non-resonant Higgs pair production via gluon-gluon fusion and as well as Vector Boson Fusion processes has been performed recently by CMS collaboration in various final state with the complete LHC Run-2 proton-proton collision data at center of mass energy of $\sqrt{s}$=13 TeV. This presentation emphasizes on the results of the production cross section of inclusive diHiggs production as well as estimates of relevant coupling parameters predicted by standard model (SM) and constraints on some of the effective couplings of HH in the beyond standard model (BSM) scenario.

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Measurement of Higgs self coupling from non-resonant Higgs pair production in CMS experiment

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Pedagogical lecture on EFT