PIKIMO Fall 2024

Saturday 16 November 2024 - Saturday 16 November 2024

Book of Abstracts

Contents

9:05-10:25 / 2

Radio Detection of Ultra High Energy Neutrinos with Askaryan Radio Array

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The Askaryan Radio Array (ARA) is an in-ice ultra high energy (UHE, >10 PeV) neutrino experiment at the South Pole that aims to detect UHE-neutrino induced radio emission in ice. ARA consists of five independent stations each consisting of a cubical lattice of in-ice antenna clusters with side length of ˜10 m buried at about 200 m below the ice surface. All five independent ARA stations have collectively accumulated about 310 TB of data over the last decade. The fifth station of ARA (A5) is special as this station has an additional central string, the phased array (PA), which provides an interferometric trigger that enables ARA to trigger on weak signals that are otherwise buried in noise. Leveraging the low threshold phased array trigger, ARA was the first radio neutrino experiment to demonstrate significant improvement in sensitivity to weak signals. In this talk, I will present initial results from a neutrino search on A5 combining information from both the traditional station antennas and the phased array antennas. We will show the improved vertex reconstruction achieved with this approach, and leveraging this improvement, we expect to enhance the analysis efficiency beyond what has been achieved previously by ARA. This analysis is the paradigmatic representation of future neutrino searches with the next generation of in-ice neutrino experiments. I will also present the current state of the first array-wide diffuse neutrino search using data from all five independent stations of ARA. We anticipate that this analysis will result in the first UHE neutrino observation or world-leading limits from a radio neutrino detector below 100 EeV. Additionally, this analysis will demonstrate the feasibility for multi-station in-ice radio arrays to successfully conduct an array-wide neutrino search, paving the way for future, large detector arrays such as RNO-G and IceCube-Gen2 Radio.

9:05-10:25 / 4

Discovering dark matter at the MUonE experiment

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The MUonE experiment aims to extract the hadronic contribution to the muon anomalous magnetic moment from a precise measurement of the muon-electron differential scattering cross section. We show that MUonE can also discover thermal relic dark matter using only its nominal experimental setup. Our search strategy is sensitive to models of dark matter in which pairs of pseudo-Dirac fermions are produced in muon-nucleus scattering in the target, and the heavier state decays semi-visibly to yield dilepton pairs displaced downstream from the interaction point. This approach can probe sub-GeV thermal-relic dark matter whose cosmological abundance is governed by the same model parameters that set the MUonE signal strength. Furthermore, our results show that the downstream ECAL plays a key role in rejecting backgrounds for this search, thereby providing strong motivation for the MUonE to keep this component in the final experimental design.

3:20-4:40 / 5

Baryogenesis from monopole catalysis of baryon decays

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Monopole, generically produced in any Unification theories, can also catalyze baryon decays at an unsuppressed rate, known as the Callan-Rubakov effect. This naturally provides a source of baryon number violation in both the early Universe and late Universe. For the first time, we propose a scenario to produce the primordial baryon asymmetry using the Callan-Rubakov effect and point out potential experimental signals.

9:05-10:25 / 6

How Matter Matters: The Story of Time Invariance Violation in Neutrino Oscillations

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While neutrino oscillations provide a well motivated probe for CP violation, non-trivial matter effects and our inability to build experiments in an anti-Earth limits our studies to improper tests of its effects. These limitations in turn motivate (from CPT theorem) time invariance studies, as under certain matter potential profiles, proper time invariance and improper time invariance are the same. With this in mind, the following talk will focus on revisiting the pedagogical study of time invariance in matter-based neutrino oscillations, providing potential consequences in the case where we have a new beam source (i.e. muon storage rings) which would allow for an experiment to make time invariance channel comparisons. We discuss the above for different types of matter potential profiles, in an effort to distinguish between intrinsic and matted-induced time invariance violation, if at all, in neutrino oscillation probabilities.

1:20-2:00 / 7

A general mass variable flavor number scheme for Z boson production in association with a heavy quark at hadron colliders

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We present a methodology to streamline implementation of massive-quark radiative contributions in calculations with a variable number of active partons in proton-proton collisions. The methodology introduces subtraction and residual heavy-quark parton distribution functions (PDFs) to implement calculations in the Aivazis-Collins-Olness-Tung (ACOT) factorization scheme and its simplified realization in various processes up to the next-to-the-next-to-leading order in the QCD coupling strength. Interpolation tables for bottom-quark subtraction and residual distributions for CT18 NLO and NNLO PDF ensembles are provided in the common LHAPDF6 format. A numerical calculation of Z-boson production with at least one b jet at the Large Hadron Collider beyond the lowest order in QCD is considered for illustration purposes.

11:00-11:40 / 8

Two-Higgs-Doublet Model Effective Field Theory

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We introduce the general two-Higgs-doublet model effective field theory where the effects of new physics are parametrized by operators up to mass dimension-six. We discuss the differences of the effective field in four types of two-Higgs-doublet models distinguished by Z_2 symmetries which restrict the couplings of the Higgs doublets to Standard Model fermions: type-I, -II, -X, and -Y. We transform the entire effective theory to the Higgs basis and show several advantages, including the separation of operators that modify Standard Model couplings and masses from operators that contribute to scattering processes only, transparent correlations between scattering processes resulting from the same operator, and derivation of correlations between different operators in specific UV completions. For example, we highlight these advantages when calculating the electric and magnetic dipole moments of the muon.

11:00-11:40 / 9

Looking for Stringy Bosenova

Author: Dawid Brzeminski[None]

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Black hole superradiance is an exciting tool to probe ultralight fields. In the case of gauge bosons, the buildup of electromagnetic fields in the superradiance cloud can lead to a phase transition, producing dark photon strings. After absorbing energy from the background gauge fields, these strings are ejected from the black hole, forming an expanding cloud. In this talk, we will explore the gravitational wave signatures of such an expanding cloud of strings, as well as the prospects for detecting remnants of the cloud if the dark photon mediates B-L charge.

1:20-2:00 / 10

Fractionally Charged Particles at the Energy Frontier

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The observed Standard Model is consistent with the existence of vector-like species with electric charge a multiple of e/6. The discovery of a fractionally charged particle would provide nonperturbative information about Standard Model physics, and furthermore rule out some or all of the minimal theories of unification. We discuss the phenomenology of such particles and focus particularly on current LHC constraints, for which we reinterpret various searches to bound a variety of fractionally charged representations. We emphasize that in some circumstances the collider bounds are surprisingly low or nonexistent, which highlights the discovery potential for these species which have distinctive signatures and important implications.

3:20-4:40 / 13

Geometry and Energy in Effective Field Theories

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The geometry of field space governs on-shell scattering amplitudes in effective field theories. Extending previous geometric descriptions for scalars and gauge fields, I will discuss how we developed a framework that incorporates fermions into the geometric formulation of effective field theories. Utilizing this field-space geometry, we reorganize and simplify quantum loop corrections, calculating the one-loop contributions to the renormalization group equations for bosonic operators in the SMEFT up to mass dimension eight. I will further discuss structures in EFT not captured by the geometric framework, namely energy-enhanced effects arising from higher-dimensional operators. In particular, I will present our study on Higgs boson production via VBF at the LHC, and capturing the leading energy-enhanced contributions within the SMEFT up to mass dimension eight. Employing energy-scaling arguments, we predict the magnitude of each higher-dimensional operator's contribution and incorporate dimension-eight operators not previously considered. Our findings suggest that dimension-eight operators can have significant effects in regimes where the SMEFT remains valid for lower cutoff scales than expected.

9:05-10:25 / 14

Electroweak-charged Dark Matter and SO(10) Unification with Parity Symmetry

Authors: Keisuke Harigaya[None]; Matthew Baldwin[None]

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We consider electroweak-charged dark matter in an $SO(10)$ unified theory that solves the strong CP problem via Parity. Electroweak-charged dark matter has a colored $SO(10)$ partner, whose mass should be much above the dark matter mass to avoid cosmological problems arising from the decay of the colored partner. The mass hierarchy can be naturally achieved by an $SO(10) \times CP$ symmetry breaking Higgs that has a missing vacuum expectation value. The mass hierarchy, via quantum corrections to the gauge coupling constants, lowers the unification scale and enhances the proton decay rate. Hyper-Kamiokande will probe the parameter space with precise gauge coupling unification. We derive the range of the top quark mass and the strong coupling constant preferred by radiative Parity breaking by the Higgs Parity mechanism.

3:20-4:40 / 15

Accidental Suppression of Wilson Coefficients in Higgs Coupling

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Higgs couplings are essential probes for physics beyond the Standard Model (BSM) since they can be modified by new physics, such as through the Higgs portal interaction $|H|^2\mathcal{O}$. These modifications influence Higgs interactions via dimension-6 operators of the form $\left(\partial|H|^2\right)^2$ and $|H|^6$, which are generally expected to be of comparable size. This talk discusses a phenomenon of accidental suppression, where the $|H|^6$ coupling is significantly smaller than $\left(\partial|H|^2\right)^2$. This suppression, arising from the truncation of the tree-level effective potential, lacks a clear symmetry explanation but persists in portal models. This talk aims to inspire further studies on additional instances of accidental suppression without symmetry explanations or a general framework to characterize such suppression. We also discuss constraints, at the HL-LHC and future colliders, on the Wilson coefficients of the two dimension-6 operators for various benchmark scenarios of the concrete model.

3:20-4:40 / 16

Confining conformal colliders

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Energy correlators are observables that have attracted attention from both collider physics and formal theory. In QCD jets, the two-point energy correlator offers a clean visualization of the confinement transition. I will present a calculation of the two-point correlator in the simplest "hard-wall" holographic model of confinement, with the aim of better understanding confinement through the lens of energy correlators. This is the first AdS/CFT computation of energy correlators in a confining theory.

The results capture some, but not all, of the qualitative features of QCD energy correlators. I will describe some initial progress toward generalizing these results to more sophisticated models of confinement.