PIKIMO 11

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Book of Abstracts

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Thermal Misalignement for Scalar Dark Mtter

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The conventional misalignment mechanism for scalar dark matter depends on the initial field value, which governs the oscillation amplitude and present-day abundance. We present a mechanism by which a feeble (Planck-suppressed) coupling of dark matter to a fermion in thermal equilibrium drives the scalar towards its high-temperature potential minimum at large field values, dynamically generating misalignment before oscillations begin. Unlike conventional misalignment production, the dark matter abundance is dictated by microphysics and not by initial conditions. As an application of the generic mechanism, we discuss a realistic scenario in which dark matter couples to the muon.

2

Directional dark matter detection in diamond: principles and experimental progress

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The next generation of weakly interacting massive particle (WIMP) dark matter (DM) detectors will be sensitive to coherent scattering of solar neutrinos from target nuclei, demanding an efficient background-signal discrimination tool. Thanks to relative motion of the Solar System and Galactic DM halo, fluxes of solar neutrinos and DM particles have distinct anisotropic flux distributions. A directional detector hence would enable detection of WIMP DM below the "neutrino floor", otherwise an irreducible background. Diamond has been proposed as a next-generation DM detector because of its sensitivity to low-mass WIMP candidates, as well as its excellent semiconductor properties at cryogenic temperatures, making it a suitable target for sub-GeV DM detection. We are developing complementary methods for nuclear recoil directionality readout in diamond. WIMP- and neutrino-induced nuclear recoils would leave a sub-micron track of lattice damage, constituting a durable signal for the incoming particle's direction. Spectroscopy of quantum defects such as nitrogen vacancy (NV) centers allows detection of crystal damage via the strain induced in the crystal lattice, while methods such as X-ray diffraction allow nanoscale mapping of crystal structure. We present the proposed directional detection principle as well as an overview of recent experimental results.

3

Precision Calculation of Inflation Correlators at One Loop

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We initiate a systematic study of precision calculation of the inflation correlators at the 1-loop level, starting in this paper with bosonic 1-loop bispectrum with chemical-potential enhancement. Such 1-loop processes could lead to important cosmological collider observables but are notoriously difficult to compute due to the lack of symmetries. We attack the problem from a direct numerical approach based on the real-time Schwinger-Keldysh formalism and show full numerical results for arbitrary kinematics containing both the oscillatory "signals" and the "backgrounds". Our results show that, while the non-oscillatory part can be one to two orders of magnitude larger, the oscillatory signal can be separated out by applying appropriate high-pass filters. We have also compared the result with analytic estimates typically adopted in the literature. While the amplitude is comparable, there is a non-negligible deviation in the frequency of the oscillatory part away from the extreme squeezed limit. See [arXiv:2109.14635] for more details.

4

Higgs boson pair production at NNLO in the large-m_t expansion

Author: Florian Herren[1]

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In this talk we present the impact of top quark–mass suppressed terms on the real-virtual and real-real NNLO corrections to the total partonic production cross section of a pair of Higgs bosons in gluon fusion.

5

Azimuthal Angular Correlation as a Boosted Top Jet Substructure

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We propose a novel jet substructure observable of boosted tops that is related to the linear polarization of the W boson in top quark decay, which results in a $\cos 2\varphi$ angular correlation between the $t \to bW$ and $W \to f\bar{f}'$ decay planes. The degree of this angular correlation can be used to measure the longitudinal polarization of top quark, which is an important probe of new physics that couples to top sector. We discuss in detail the origin of such linear polarization, by applying Wigner's little group transformation. We show that the unique $\cos 2\varphi$ angular correlation only exists in the boosted regime, but not in the top quark rest frame, and can discriminate a boosted top quark jet from its background events, such as QCD jets.

6

Exploring the phenomenology of weak adjoint scalars in minimal R-symmetric models

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We examine the phenomenology of the scalar fields in weak and Higgs sectors of minimal R-symmetric models, in particular the 'swino' and 'sbino', the scalar partners to the chiral fields that marry the electroweak gauge bosons in Dirac gaugino models. These fields are in adjoint representations of SU(2) and U(1) and have both CP-even and CP-odd components. The interactions of these new states are summarized, and decay widths are computed analytically to one loop order. We discuss the tree level contributions of these new states to the mass spectrum of MSSM sfermions. We also explore production cross sections and decay signatures at colliders for several chosen benchmarks. We find that large regions of parameter space are unconstrained by present collider data.

7

Searching for heavy dark matter in direct detection experiments

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Parameter space near the Planck mass (~10^{19}GeV/c^2) remains relatively unexplored, while many interesting heavy particle dark matter models exist. Multiply-interacting massive particles (MIMPs) are heavy dark matter particles that interact heavily with regular matter but may have evaded detection due to the low number density required to make up the local dark matter halo. These particles could leave track-like signatures in current experiments, like the MAJORANA Demonstrator and XENON1T, similar to lightly-ionizing particles. In this talk, I extend the current leading WIMP search result from XENON1T single scatter signal to this high-mass regime for MIMPs search, and present a dedicated analysis to search for multiply scattered MIMP track-like signals in XENON1T data.

8

Hidden Naturalness in the Light of Precision Cosmological Data

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Hidden naturalness offers an exciting framework for alleviating the Higgs hierarchy problem. However, since the models within this framework face few constraints from collider searches, there is strong motivation to study their cosmological signatures, an area that has remained mostly unexplored. One of the simplest models that can be studied in this framework is the mirror twin Higgs (MTH) model, a model that contains a near-mirror copy of the SM. Cosmologically, the MTH model is quite complex, containing new sources of free-streaming radiation, interacting radiation, and interacting dark matter. In the seminar, I will discuss how cosmological datasets, including the CMB temperature and polarization power spectra as measured by the Planck collaboration, can be used to probe the parameter space of the MTH model. In addition, I will also show how this model may help in ameliorating the tensions in the cosmological datasets, specifically those related to the σ_8 and H_0 measurements.

9

Indirect Detection of Secluded Supersymmetric Dark Matter

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Weak-scale secluded sector dark matter can reproduce the observed dark matter relic density with thermal freeze-out within that sector. If nature is supersymmetric, three portals to the visible sector - a gauge portal, a Higgs portal, and a gaugino portal - are present. We present gamma ray spectra relevant for indirect detection of dark matter annihilation in such setups. Since symmetries in the secluded sector can stabilize dark matter, R-parity is unnecessary, and we investigate the impact of R-parity violation on annihilation spectra. We present limits from the Fermi Large Area Telescope observations of dwarf galaxies and projections for Cherenkov Telescope Array observations of the galactic center. Many of our results are also applicable to generic, non-supersymmetric setups.

10

Free-streaming and Coupled Dark Radiation Isocurvature Perturbations: Constraints and Application to the Hubble Tension

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Dark radiation (DR) appears as a new physics candidate in various scenarios beyond the Standard Model. While it is often assumed that perturbations in DR are adiabatic, they can easily have an isocurvature component if more than one field was present during inflation, and whose decay products did not all thermalize with each other. In this talk, I will discuss the constraints on both uncorrelated and correlated DR density isocurvature perturbations from the full Planck 2018 data alone, and also in combination with other cosmological data sets. Our work on free-streaming DR (FDR) updates and generalizes the existing bound on neutrino density isocurvature perturbations by including a varying number of relativistic degrees of freedom. In the case of coupled DR (CDR) isocurvature, we derive the first bound. I will also discuss that for isocurvature IC, FDR gives rise to larger CMB anisotropies compared to CDR – contrary to the adiabatic case. More generally, we find that a blue-tilt of DR isocurvature spectrum is preferred from the cosmological data. This gives rise to a larger value of the Hubble constant H_0 compared to the standard ΛCDM+$\Delta N_{\rm eff}$ cosmology with adiabatic spectra and relaxes the Hubble tension.

11

Two-loop Electroweak Corrections to the Top-Quark Contribution to ϵ_K

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The parameter ϵ_K measures CP violation in the neutral kaon system. It is a sensitive probe of new physics and plays a prominent role in the global fit of the Cabibbo-Kobabyashi-Maskawa matrix. The perturbative theory uncertainty is currently dominated by the top-quark contribution. In this talk I will present the calculation of the full two-loop electroweak corrections to the top-quark contribution to ϵ_K, including the resummation of QED-QCD logarithms. I will also discuss different renormalization prescriptions for the electroweak input parameters. In the traditional normalization of the weak Hamiltonian with two powers of the Fermi constant G_F, the top-quark contribution is shifted by -1%.

12

Multi-Boson Production and the Muon Yukawa Coupling

Authors: Juergen Reuter[1]; Keping Xie[2]; Nils Kreher[3]; Tao Han[None]; Tobias Striegl[3]; Wolfgang Kilian[3]; Yang Ma[2]

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The Higgs boson may be regarded as, on the one hand, the capstone of the glorious arch of the SM or, on the other hand, as the portal giving access to new physics. An open question in particle physics is whether the Higgs mechanism generates the masses of all the fermions by the Yukawa interactions. We propose to study multi-boson production processes and scrutinize the muon Yukawa coupling at a high-energy muon collider. By the subtle interplay between the muon Yukawa coupling in the high-energy productions of multiple (vector and Higgs) bosons, we show that it is possible to measure the muon Yukawa coupling to an accuracy of ten percent for a 10 TeV collider and a few percent for a 30 TeV machine.

13

Windchime: Gravitational Detection of Dark Matter with Mechanical Sensors

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The Windchime experiment endeavors to directly detect dark matter through its gravitational interaction alone. Current direct dark matter searches rely on the possibility of much stronger non-gravitational interactions of dark matter with ordinary matter. However, dark matter is only guaranteed to interact gravitationally. At a well-motivated mass range of 10ˆ19 GeV, it is conceivable to detect the gravitational impulse of a passing particle. We pursue four avenues of technological development to achieve gravitational sensitivity: sensor development and production, environmental isolation, quantum noise reduction, and computing with large data sets for track finding. Ultimately, Windchime will consist of an array of 10ˆ9 optomechanical accelerometers operating at their thermal noise limit in ultra-high vacuum at 10mK, so that passing heavy dark matter particles are recorded as tracks in the array.

14

Evolution of AI approaches at the LHC

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In this talk, we will review recent deep learning strategies, and talk about the progression of deep learning embeddings of data. We then follow with this by talking about recent work on supervised and weak supervised learning approaches and how they can play an integral role in next generation physics searches. Finally, we will comment briefly on recent experimental trends at the LHC, and how these tools are being integrated for further use.

15

Kaleidoscope of axion models and probes

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Axions, periodic pseudo-scalars, enjoy a wide range of phenomenological applications, from solving the strong CP problem to providing DM and inflaton candidates. Justifiably, they have been the subject of prolonged theoretical interest, which has intensified over the past few years. In this talk, I will discuss several fun developments in axion models and probes, including: a recently identified source of axion potential, novel astrophysical probes such as axion echos from supernova remnants and cosmic distance measurements, and new cosmological models of QCD axion dark matter.

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Nanosecond machine learning event classification with boosted decision trees in FPGA for high energy physics

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A novel implementation of boosted decision trees on FPGA is presented as a case study for use in a real-time trigger system at the LHC and HL-LHC. An example case of vector boson fusion production of the Higgs boson followed by its hypothetical decay into invisible or soft final states is considered. Comparison of hardware performance is made with respect to hls4ml's boosted decision trees as well as to hls4ml's neural network.

https://arxiv.org/abs/2104.03408