PIKIMO Spring 2024

Report of Contributions

https://indico.cern.ch/e/1384179

Contribution ID: **1** Type: **not specified**

Generalized Global Symmetries and Nonperturbative Quantum Flavodynamics

Saturday, 4 May 2024 10:55 (20 minutes)

Generalized global symmetries are present in theories of particle physics, and understanding their structure can give insight into these theories and UV completions thereof. We will identify non-invertible chiral symmetries in certain flavorful Z' extensions of the Standard Model, and this will lead us to interesting nonperturbative effects in theories of gauged non-Abelian flavor. For the leptons we will find naturally exponentially small Dirac neutrino masses. In the quark sector, a certain symmetry exists specially because we have the same numbers of colors and generations, and leads us to a massless down-type quarks solution to strong CP in color-flavor unification.

Are you willing to consider presenting a poster instead?

No

Primary author: KOREN, Seth (University of Notre Dame)

Presenter: KOREN, Seth (University of Notre Dame)

Session Classification: Talks

Contribution ID: **2** Type: **not specified**

Detecting Axion Dark Matter with Black Hole Polarimetry

Saturday, 4 May 2024 09:35 (20 minutes)

The axion, as a leading dark matter candidate, is the target of many on-going and proposed experimental searches based on its coupling to photons. Ultralight axions that couple to photons can also cause polarization rotation of light which can be probed by cosmic microwave background. In this work, we show that a large axion field is inevitably developed around black holes due to the Bose-Einstein condensation of axions, enhancing the induced birefringence effects. Therefore, we propose measuring the modulation of supermassive black hole imaging polarization angles as a new probe to the axion-photon coupling of axion dark matter. The oscillating axion field around black holes induces polarization rotation on the black hole image, which is detectable and distinguishable from astrophysical effects on the polarization angle, as it exhibits distinctive temporal variability and frequency invariability. We present the range of axion-photon couplings within the axion mass range $10^{-21} - 10^{-16}$ eV that can be probed by the Event Horizon Telescope. The axion parameter space probed by black hole polarimetry will expand with the improvement in sensitivity on the polarization measurement and more black hole polarimetry targets with determined black hole masses.

Are you willing to consider presenting a poster instead?

No

Primary authors: XIAO, Huangyu (Fermilab); Prof. WANG, Lian-Tao (University of Chicago); GAN, Xucheng

Presenter: GAN, Xucheng

Session Classification: Talks

Contribution ID: **3** Type: **not specified**

Visible Axinovae: Axion Star Explosions with Photon Emissions

Saturday, 4 May 2024 10:35 (20 minutes)

Axion dark matter or any ultralight bosonic dark matter can go through Bose-Einstein condensation due to the large phase density, leading to the formation of axion stars or solitons in the halo center. The formation rate is further enhanced in the presence of substructures such axion miniclusters which are expected in the post-inflationary scenario of the QCD axion or axion-like particles. Axion stars will continue to growth until its critical mass is reached, after which axion stars collapsed to the dense branch and explode along with the emission of relativistic axions, called axinovae. However, the photon emission channel can be turned on during the explosion of axion stars due to the stimulated decay of axions in coherent compact axion stars. We study the condition of axion model parameters that leads to a significant emission of photons in comparison to the emission of relativistic axions. We found that axinovae will contain a significant amount of visible photons when κ
$gtrsim64\,(f_a/10^{10}\mathrm{GeV})^{1/3}$ where κ represents the strength of the axion-photon coupling with respect to the axion self-coupling, $g_{a\gamma} = \kappa\alpha/(2\pi f_a)$. We point out that an slight enhancement on the axion-photon coupling compared to self-interaction is required to make axinovae visible. The condition of forming axion stars and triggering axinovae is also systematically studied, which reveals axion parameter space that can lead to bright radio axinovae that is ruled out by radio transient searches. If the axion mass corresponds to a frequency much lower than radio frequencies, it points out an interesting signal to search for that involves low energy photon emission from axion star explosions.

Are you willing to consider presenting a poster instead?

No

Primary authors: XIAO, Huangyu (Fermilab); WEINER, Neal; FOX, Patrick J.

Presenter: XIAO, Huangyu (Fermilab)

Session Classification: Talks

Contribution ID: **4** Type: **not specified**

Crescendo Beyond the Horizon: More Gravitational Waves from Domain Walls Bounded by Inflated Cosmic Strings

Saturday, 4 May 2024 16:50 (20 minutes)

Gravitational-wave (GW) signals offer unique probes into the early universe dynamics, particularly those from topological defects. We investigate a scenario involving a two-step phase transition resulting in a network of domain walls bound by cosmic strings. By introducing a period of inflation between the two phase transitions, we show that the stochastic GW signal can be greatly enhanced. The generality of the mechanism also allows the resulting signal to appear in a broad range of frequencies and can be discovered by a multitude of future probes, such as Pulsar Timing Arrays, and space- and ground-based observatories. We also offer a concrete model realization that relates the second phase transition to the epoch of inflation. In this model, the successful detection of the GW spectrum peak pinpoints the soft supersymmetry breaking scale and the domain wall tension.

Are you willing to consider presenting a poster instead?

No

Primary authors: HARIGAYA, Keisuke (University of Chicago); WANG, Liantao (University of Chicago); BAO, Yunjia (University of Chicago)

Presenter: BAO, Yunjia (University of Chicago)

Session Classification: Talks

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

Large Blue Spectral Index From a Conformal Limit of a Rotating Complex Scalar

Saturday, 4 May 2024 14:15 (20 minutes)

One well known method of generating a large blue spectral index for axionic isocurvature perturbations is through a flat direction not having a quartic potential term for the radial partner of the axion field. In this work, we show how one can obtain a large blue spectral index even with a quartic potential term associated with the Peccei-Quinn symmetry breaking radial partner. We use the fact that a large radial direction with a quartic term can naturally induce a conformal limit which generates an isocurvature spectral index of 3 (corresponding to the dimensionless spectrum scaling as wave vector squared). Another way to view this limit is to use the angular momentum of the initial conditions to slow down the radial field. Quantization of the non-static system in which derivative of the radial field and the derivative of the angular field do not commute is treated with great care to compute the vacuum state. The parametric region consistent with dark matter and isocurvature cosmology is discussed.

Are you willing to consider presenting a poster instead?

No

Primary author: TADEPALLI, SAI CHAITANYA

Co-author: Prof. CHUNG, Daniel (Dept of Physics, University of Wisconsin Madison)

Presenter: TADEPALLI, SAI CHAITANYA

Session Classification: Talks

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

Statistics of axion wind detection with superfluid Helium-3

Saturday, 4 May 2024 09:55 (20 minutes)

The homogeneous precession domain (HPD) of superfluid ^{3}He has recently been identified as a detection medium which might provide sensitivity to the axion-nucleon coupling g_{aNN} competitive with, or surpassing, existing experimental proposals. In this work, we make a detailed study of the statistical and dynamical properties of the HPD system in order to make realistic projections for a full-fledged experimental program. We include the effects of clock error and measurement error in a concrete readout scheme using superconducting qubits and quantum metrology. This work also provides a more general framework to describe the statistics associated with the axion gradient coupling through the treatment of a transient resonance with a non-stationary background in a time-series analysis. Incorporating an optimal data-taking and analysis strategy, we project a sensitivity approaching $g_{aNN} \sim 10^{-12}$ GeV^{-1} across a decade in axion mass.

Are you willing to consider presenting a poster instead?

Yes

Primary author: FOSTER, Joshua (Massachusetts Institute of Technology)

Co-authors: MANDE, Aarav; GAO, Christina; SCHUETTE ENGEL, Jan (UC Berkeley); SCOTT, John (Northwestern University); NGUYEN, Man (Northwestern University); HALPERIN, William (Northwestern University); KAHN, Yonatan

Presenter: MANDE, Aarav

Session Classification: Talks

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

A tale of tails via QCD insights

Saturday, 4 May 2024 16:10 (20 minutes)

The first observation of gravitational waves nearly ten years ago has ushered us into the age of gravitational wave astrophysics. With an eye towards the precision of future detectors, improving theoretical understanding of gravitational wave dynamics is a necessity. In this talk, I will discuss my work on importing methods and insights from particle physics into the study of a piece of the gravitational waves problem: the tail effects. These are a collection of effects that result from handling the non-linear effects of gravitating systems including, but not limited to, binary black hole systems in a near-zone/far-zone splitting. They are particularly interesting because they are both dissipative and hereditary, and induce a renormalization group flow related to the classical source couplings. Using this novel approach opened up a new state-of-the-art with respect to tail effects, exceeding the current reach of traditional field theory frameworks.

Are you willing to consider presenting a poster instead?

No

Primary author: EDISON, Alex (Northwestern University)

Co-author: Dr LEVI, Michèle (Oxford University)

Presenter: EDISON, Alex (Northwestern University)

Session Classification: Talks

Contribution ID: **8** Type: **not specified**

Multi-electron muon decays

Saturday, 4 May 2024 13:55 (20 minutes)

We study the exotic muon decays with five charged tracks in the final state. First, we investigate the Standard Model rate for $\mu \to eeeee\nu\nu$ and find that the Mu3e experiment should have tens to hundreds of signal events per 10^{15} μ^+ decays, depending on the signal selection strategy. We then turn to a neutrinoless $\mu \to eeeee$ decay that may arise in new-physics models with lepton-flavor-violating effective operators involving a dark Higgs h_d. We show that a $\mu \to eeeee$ search at the Mu3e experiment, with potential sensitivity to the branching ratio at the $\mathcal{O}(10^{-12})$ level or below, can explore new regions of parameter space and new physics scales as high as $\Lambda \sim 10^{15}$~GeV.

Are you willing to consider presenting a poster instead?

No

Primary author: MENZO, Tony

Presenter: MENZO, Tony

Session Classification: Talks

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

Amplifying CMB phase shift with dark matter-radiation interactions

Saturday, 4 May 2024 11:15 (20 minutes)

The peaks of the CMB spectra provide a direct cosmological probe for studying dark sector physics. Specifically, a shift in the peak positions corresponds to a phase shift in the acoustic oscillations of the photon-baryon plasma before recombination, which is sensitive to the propagation behavior of non-photon radiation. It has been established that CMB spectra shift to higher l-modes if the non-photon radiation is self-interacting rather than free-streaming. In this talk, I will show that this phase shift can be further amplified if the non-photon radiation, which includes neutrinos or dark radiation, interacts with dark matter. Using neutrino-dark matter scattering as an example, we numerically calculate the amplified phase shift and offer an analytical interpretation of the result by modelling photon and neutrino perturbations with coupled harmonic oscillators. When the energy density of the interacting radiation exceeds that of the interacting dark matter at matter radiation equality, we find that the phase shift enhancement is proportional to the interacting dark matter abundance but rather insensitive to the abundance of interacting radiation. This additional phase shift emerges as a generic signature of models featuring neutrino-dark matter scattering, or a dark sector with dark matter-radiation interaction.

Are you willing to consider presenting a poster instead?

No

Primary authors: HO, Daven Wei Ren; Dr GHOSH, Subhajit (The University of Texas at Austin); TSAI, Yuhsin (University of Notre Dame)

Presenter: HO, Daven Wei Ren

Session Classification: Talks

Contribution ID: **10** Type: **not specified**

Topological aspects of particle production in the early universe

Saturday, 4 May 2024 14:35 (20 minutes)

We study topological aspects of particle production using Stokes phenomenon. An explicit map between the standard β-coefficient computation, and Stokes constants from the perspective of the F-matrix formalism is presented. In scenarios where the particle dispersion relation reduces in the long wavelength limit ($k \to 0$) to the form z^n ($n \in \mathbb{Z}_{>0}$) in complexified time z, the corresponding mode equation satisfies a $\mathbb{Z}_{n+2}$ symmetry. This symmetry, combined with the F-matrix formalism fixes the Stokes constants and the β-coefficient as simple trigonometric functions of n. Here we extend the above computation to small non-zero values of k by computing the lowest order corrections to the Stokes constants for scenarios where the mode equation retains a $\mathbb{Z}_{n+2}$ symmetry. These corrections are then used to estimate the topological contribution corresponding to $k \approx 0$ to the total particle production in two scalar field models of interest for early universe cosmology.

Are you willing to consider presenting a poster instead?

No

Primary authors: Prof. CHUNG, Daniel (University of Wisconsin-Madison); Ms SUDHIR, Nidhi (University of Wisconin-Madison)

Presenter: Ms SUDHIR, Nidhi (University of Wisconin-Madison)

Session Classification: Talks

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

Seeing highly anisotropic gravitational wave backgrounds from the early universe

Saturday, 4 May 2024 16:30 (20 minutes)

A stochastic gravitational wave background (GWB) produced in the early universe would necessarily exhibit anisotropies analogous to the CMB. In multi-field inflationary scenarios, anisotropies in GWB could differ significantly from those of the CMB if sourced by a quantum field different from the one sourcing CMB. In these scenarios, however, the more interesting case of highly anisotropic GWB typically comes at the cost of suppressed isotropic part. In this talk, I will present models of modified post-inflationary cosmology in which this tradeoff can be made less severe. Such models significantly improve the detection prospect of these novel GWB anisotropy maps at future GW detectors.

Are you willing to consider presenting a poster instead?

No

Primary author: BODAS, Arushi (University of Chicago and Fermilab)

Presenter: BODAS, Arushi (University of Chicago and Fermilab)

Session Classification: Talks

Contribution ID: **12** Type: **not specified**

CHIME is Secretly an Axion Experiment

Saturday, 4 May 2024 13:00 (55 minutes)

In the presence of radiation from bright astrophysical sources at radio frequencies, axion dark matter can undergo stimulated decay to two nearly back-to-back photons, meaning that bright sources could have faint counterimages in other parts of the sky. The counterimages will be spectrally distinct from backgrounds, taking the form of a narrow radio line centered at half the axion mass with a spectral width determined by Doppler broadening in the dark matter halo. In essence, axions behave as an imperfect monochromatic mirror. The morphology of the induced images can be nontrivial, with blurring due to the geometry of the source and image as well as spatial smearing due to the galactic kinematics of axion dark matter. I will show that the axion decay-induced counterimages of galactic sources may be bright enough to be detectable with archival data from CHIME and other ongoing or planned radio surveys. CHIME therefore can run as a competitive axion experiment simultaneously with other science objectives, requiring no new hardware.

Are you willing to consider presenting a poster instead?

Primary author: Prof. SCHUTZ, Katelin

Presenter: Prof. SCHUTZ, Katelin

Session Classification: Invited Talk

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

Tortured Phenomenology Department, or why we need quantum computers

Saturday, 4 May 2024 15:15 (55 minutes)

Many problems across high energy physics may ultimately prove impossible to solve without the assistance of quantum computers. While much progress has been made in the last decade to understand and formulate these problems, much work remains to be done. In this talk, we will highlight some of the outstanding issues to making predictions in HEP on these devices, and how HEP-insights might accelerate the development of these computers.

Are you willing to consider presenting a poster instead?

No

Primary author: LAMM, Hank

Presenter: LAMM, Hank

Session Classification: Invited Talk