2nd Topics of Particle, Astro and Cosmo Frontiers (TOPAC 2024)

Thursday, 30 May 2024 - Sunday, 2 June 2024

Southeast University (Sipailou Campus)

Book of Abstracts

Contents

Poster session and dinner / **1**

Prospects for testing gravity with pulsars around Sagittarius A*

Author: Zexin Hu[1]

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Future observation with next-generation large-area radio telescopes are expected to discover radio pulsars closely orbiting around Sagittarius A*(Sgr A)*, the supermassive black hole (SMBH) in our Galactic Center (GC). Such a system can provide a unique laboratory for testing gravity theories , as well as the astrophysics around the GC. We will introduce our recent studies about prospects for using the SMBH-pulsar system to test gravity. Including testing the no-hair theorem in General Relativity, constraining the vector charge of Sgr A, *probing the small-scale dark matter distribution around Sgr A* and so on.

Paper info:

arxiv:2312.01889; arxiv:2312.02486

Flavor / **2**

Recent progress of Dark SHINE R&D

Author: Shu Li[1]

[1] *TDLI, SJTU*

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Dark SHINE is a newly proposed fixed-target experiment at SHINE (Shanghai high repetition rate XFEL and extreme light facility, being the 1st hard X-ray FEL in China) under construction targeting completion in 2026. Dark SHINE aims to search for the new mediator, Dark Photon, bridging the Dark sector and the ordinary matter. In this work and presentation, we present the idea of this new project and 1st prospective study in search for Dark Photon decaying into light dark matter. It also provides the opportunity to incorporate broader scope of BSM search ideas such as ALP, utilizing the fixed-target experiment of this type.

Paper info:

Experiments / **3**

Recent ATLAS results of Dark Matter and Dark Photon combinations and Dark Higgs searches

Author: Shu Li[1]

[1] *TDLI, SJTU*

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Ref: https://arxiv.org/abs/2306.00641

Results from a wide range of searches targeting different experimental signatures with and without missing transverse momentum (E_T^{miss}) are used to constrain a Two-Higgs-Doublet Model (2HDM) with an additional pseudo-scalar mediating the interaction between ordinary and dark matter (2HDM+a). The analyses use up to 139 fb^{-1} of proton-proton collision data at a centre-of-mass energy $\sqrt{s}$ = 13 TeV recorded with the ATLAS detector at the Large Hadron Collider between 2015-2018. The results from three of the most sensitive searches are combined statistically. These searches target signatures with large EmissT and a leptonically decaying Z boson; large E_T^{miss} and a Higgs boson decaying to bottom quarks; and production of charged Higgs bosons in final states with top and bottom quarks, respectively. Constraints are derived for several common as well as new benchmark scenarios within the 2HDM+a.

Ref. ATLAS-CONF-2024-004
A first dedicated search is performed for dark matter particles produced in association with a resonantly produced pair of b-quarks with m(bb) < 150 GeV using 140 fb^{-1} of proton-proton collisions recorded by the ATLAS detector at a center-of-mass energy of 13 TeV. This signature is expected in extensions of the Standard Model predicting the production of dark matter particles, in particular those containing dark Higgs bosons. This search uses a novel experimental method to extend the experimental reach to lower bb-pair invariant masses, considers a wider range of dark Higgs boson interpretations and excludes new regions of parameter space for this model. For dark Higgs boson masses between 30 and 150 GeV, Z′ mediator masses up to 3.4 TeV and 4.8 TeV are excluded for benchmark scenarios.

Paper info:

Astrophysics / **5**

Cosmological phase transitions in the Holographic models for the composite Higgs boson

Authors: Oleg Novikov[1]; Andrey Shavrin[2]; Anastasia Zueva[1]

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The composite Higgs boson scenario assumes the existence of a new strongly coupled gauge sector with a softly broken approximate hyperflavor symmetry. At low energies the corresponding dynamics may be studied with help of the holographic techniques inspired by AdS/QCD. We present the bottom-up soft-wall holographic model that admits a first-order phase transition and, using a perturbation theory near the critical point, describe the production of the gravitational wave background by bubble nucleation processes in the thin-wall approximation. We also employ the approximation of the large number of spacetime dimensions to describe inhomogeneous black hole solutions dual to the gauge sector behavior in the bubble wall.

Paper info:

O.O.Novikov, A.A.Shavrin // Phys.Rev.D 108 (2023) 11, 115011

Higgs / **6**

Dark photon effects with the kinetic and mass mixing in Z boson decay processes

Author: Jin Sun[1]

[1] *Institute for Basic Science (IBS)*

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Motivated by the most recent measurement of tau polarization in $Z \to \tau^+\tau^-$ by CMS, we have introduced a new $U(1)_X$ gauge boson field X, which can have renormalizable kinetic mixing with the standard model $U(1)_Y$ gauge boson field Y.
In addition to the kinetic mixing of the dark photon, denoted as σ, there may also be mass mixing introduced by the additional Higgs doublet with a vacuum expectation value (vev) participating in $U(1)_X$ and electroweak symmetry breaking simultaneously.
The interaction of the Z boson with the SM leptons is modified by the introduction of the mixing ratio parameter ϵ, which quantifies the magnitude of both the mass and kinetic mixing of the dark photon.
Initially, we use the tau lepton as an example to explore the Z boson phenomenology of the dark photon model with both kinetic and mass mixing. The goal is to determine the allowed parameter regions by taking into account constraints from the vector and axial-vector couplings $g^{\tau}_{V,A}$, the decay branching ratio $Br(Z \to \tau^-\tau^+)$ and tau lepton polarization in $Z \to \tau^-\tau^+$. We found that the mixing ratio plays important role in the Z boson features by choosing different ϵ values.
Furthermore, we aim to generalize our analysis from the tau-lepton case to include all fermions by conducting global fits. This allows us to identify viable regions by incorporating relevant fermion constraints and the W/Z mass ratio.
Correspondingly, we obtain the fit results with the kinetic mixing parameter $\sigma = 0.074 \pm 0.021$, mixing ratio $\epsilon = -1.37 \pm 0.46$, and dark photon mass $m_X = 275 \pm 39$ GeV. Our global analysis indicates a preference for a dark photon mass larger than m_Z.

Paper info:

Neutrino / **8**

Predictions of m_ee and neutrino mass from a consistent Froggatt-Nielsen model

Author: Jin-Wei Wang[1]

[1] *UESTC*

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The seesaw mechanism is the most attractive mechanism to explain the small neutrino masses, which predicts the neutrinoless double beta decay (0νββ) of the nucleus. Thus the discovery of 0νββ is extremely important for future particle physics. However, the present data on the neutrino oscillation is not sufficient to predict the value of m_{ee} as well as the neutrino mass m^i. In this talk, by adopting a simple and consistent Froggatt-Nielsen model, which can well explain the observed masses and mixing angles of quark and lepton sectors, we calculate the distribution of m_{ee} and m^i. Interestingly, a relatively large part of the preferred parameter space can be detected in the near future.

Paper info:

DM / **10**

Multi-messenger probes on dark matter surrounding black holes

Author: kenji kadotaN[one]

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The environment around the black hole can provide us with a promising playground to study the dark matter properties because of the large dark matter density from accretion.

I will explore the multi-messenger probes on the dark matter in the vicinity of black holes. More concretely, I will discuss (1) the multi-wavelength signals covering the radio, CMB and gamma rays which can arise from the dark matter annihilation/decay (2) the gravitational wave signals from a black hole binary whose dynamics is affected by the dark matter.

Paper info:

2312.02707, 2403.06203, 2306.10828

GW / 12

Revisiting the fermion-field non-topological solitons and primordial black holes

Author: Ke-Pan Xie[1]

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Paper info:

GW / 13

Graviton-photon conversion in atomic electric fields and high frequency gravitational wave detections

Authors: Gui-Rong Liang[1]; Jin DaiN[one]

[1] *China University of Mining and Technology*

Corresponding Author: bluelgr@sina.com

We study graviton-photon conversion in potential ground-based experiments. From graviton to photon transition, we calculate the cross section of graviton-atom interaction in the presence of spherical atomic electric fields; the obtained results hold for graviton energy around 100 keV to 1 GeV, and would be enhanced along the coherent length in extremely high frequencies; thus it gives a chance to catch MeV level gravitons from the universe with current neutrino facilities. From photon to graviton transition, we propose an experiment using entangled photon pairs to count missing photons passing through transverse magnetic tunnel, which could be used to verify the energy quantization of gravitational field.

Paper info:

https://arxiv.org/abs/2302.07044

DM / 15

Freeze-in Dark Matter Explanation of the Galactic 511˜keV Signal

Author: Wan-Zhe Feng[1]

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We demonstrate, for the first time, the freeze-in dark matter, constituting 100% of the relic density can completely explain the Galactic 511 keV photon signal. In the talk, I will present two simple models for illustration. In both scenarios, the freeze-in mechanism generates the entire dark matter relic density, and thus any types of additional dark matter components produced from other sources are unnecessary.

Paper info:

to be submitted

Poster session and dinner / 17

The SM expected branching ratio for h→γγ and an excess for h→Zγ

Authors: Chia-Wei Liu[1]; Ming-Wei Li[1]; Xiao-gang He[1]; Zhonglv Huang[1]

[1] *TDLI*

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Combination of recent measurements for $h \to Z\gamma$ from ALTLAS and CMS shows an excess that the ratio of the observed and standard model (SM) predicted branching ratios $\mu = (\sigma \cdot calB)_{\rm obs}/(\sigma \cdot calB)_{\rm SM}$ is 2.2 ± 0.7. If confirmed, it is a signal of new physics (NP) beyond SM. We study NP explanation for this excess. In general, for a given model it also affects the process $h \to \gamma\gamma$. Since measured branching ratio for this process agrees with SM prediction well, the model is constrained severely. We find that a minimally fermion singlets and doublet extended NP model can explain simultaneously the current data for $h \to Z\gamma$ and $h \to \gamma\gamma$. There are two solutions. One is the SM amplitude $c_Z^{\rm SM}$ is enhanced by δc_Z for $h \to Z\gamma$ to the observed value, but the $h \to \gamma\gamma$ amplitude $c_\gamma^{\rm SM} + \delta c_\gamma$ is decreased to $-c_\gamma^{\rm SM}$ to give the observed branching ratio. This seems to be a contrived solution that although cannot be ruled out simply using branching ratio measurements. We, however, find another solution which naturally enhances the $h \to Z\gamma$ to the measured value, but keeps the $h \to \gamma\gamma$ close to its SM prediction. We also comment on some phenomenology of these new fermions.

Paper info:

Astrophysics / 18

Recent Status and Results of the Dark Matter Particle Explorer

Author: Lei Feng[1]

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Corresponding Author: fenglei@pmo.ac.cn

DAMPE 是一颗空间宇宙线探测器，于 2015 年 12 月成功发射，并在轨运行多年，已经取得多项科学成果。DAMPE 主要的科学目标有暗物质间接探测、宇宙线物理和高能伽马射线天文学。本报告重点介绍 DAMPE 的探测器研制，合作组组成和在轨运行情况。并介绍 DAMPE 已取得的科学成果，以及数据的物理解读。

Paper info:

Higgs / 19

Higgs properties and new physics beyond the SM

Author: Bin Yan[1]

[1] *IHEP*

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The discovery of the Higgs boson at the Large Hadron Collider (LHC) has opened a new era in particle physics.
Precise measurements of the properties of the Higgs boson are crucial for addressing several fundamental questions
in the field. These include understanding the mechanism behind electroweak symmetry breaking, unraveling the origin of particle masses, and exploring potential sources of CP violation
that could explain the matter-antimatter asymmetry in the universe, and so on.
In this talk, I will provide an overview of the recent advancements in Higgs physics,
both within the framework of the Standard Model (SM) and beyond.
By examining the latest research, we will gain insights into the properties and behavior of the Higgs boson,
shedding light on the fundamental workings of the universe.

Paper info:

Poster session and dinner / 20

The neutral scalars of 2HDM+S model under the LHC

Authors: Cheng Li[1]; Wei Su[2]

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[2] *SYSU*

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The 2HDM+S is the singlet extension of 2HDM, which can accommodate more physics potential beyond the SM. We summarize the type II 2HDM+S model with various Higgs potential structures, and discuss several scenarios with different mass hierarchy. In this study, we concentrate on the mass eigenstate of the 2HDM+S, and test the parameter space of Higgs mixing angles and masses against the experimental constraints, including 125 GeV Higgs measurements, BSM Higgs direct searches, STU and B-physics observables. In particular, we study the exotic channels of $h_{125} \to A_S A_S$ and $h_{125} \to h_S h_S$ decays for the light singlet-like Higgs scenarios $m_{h_S/A_S} < 62.5$ GeV, and determine the limit of Higgs mixing angles. Furthermore, we study the phenomenological distinction between 2HDM+S and 2HDM, and explore the indirect impact of the singlet admixture on the parameter space of $\cos(\beta - \alpha_1)$, $\tan\beta$ and m_A.

Paper info:

DM / **21**

Quantum Theory of Dark Matter Scattering

Author: Takumi Kuwahara[1]

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Corresponding Author: takumi.kuwahara.hep@gmail.com

Dark matter self-scattering is one of key ingredients for small-scale structure of the Universe, while dark matter annihilation is important for the indirect measurements. There is a strong correlation between the velocity-dependent self-scattering cross section and the Sommerfeld enhancement factor for the dark matter annihilation cross section. In this study, we formulate a direct relation between them by the use of Watson's (initial state/final state) theorem and Omnès solution, and our formulation reproduces the Sommerfeld enhancement factor, which directly computed by solving the Schrödinger equation, from the scattering phase shift.

Paper info:

Higgs / **22**

GKZ hypergeometric systems of four-loop vacuum Feynman integrals

Author: Hai-Bin Zhang[1]

Co-author: Tai-Fu Feng [1]

[1] *Hebei University*

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We present GKZ hypergeometric systems of four-loop vacuum Feynman integrals.

Paper info:

arXiv: 2403.13025

Poster session and dinner / **24**

Aiming for Tops of ALPs with a Muon Collider

Authors: So ChigusaN[one]; Sudhakantha Girmohanta[1]; Yufei ZhangN[one]; Yuichiro NakaiN[one]

[1] *Tsung-Dao Lee Institute and Shanghai Jiao Tong University*

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Future muon colliders with center-of-mass energy of $\mathcal{O}(1-10)$ TeV can provide a clean high-energy environment with advantages in searches for TeV-scale axion-like particles (ALPs), pseudo-Nambu–Goldstone bosons associated with spontaneously broken global symmetries, which are widely predicted in physics beyond the Standard Model (SM). We exploit ALP couplings to SM fermions, and guided by unitarity constraints, build a search strategy focusing on the ALP decay to top quark pairs at muon colliders. It is found that a large parameter space of TeV-scale ALPs with TeV-scale decay constants can be probed by utilizing the ALP-top quark coupling.

Paper info:

Poster session and dinner / **25**

Detecting Quadratically Coupled Ultra-light Dark Matter with Stimulated Annihilation

Author: Yuanlin Gong[1]

Co-authors: Bin Zhu [2]; Lei Wu [1]; Qiaoli Yang [3]; Xin Liu [1]

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[2] *Yantai University*

[3] *Jinan university*

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Ultra-light Dark Matter (ULDM) is one of the most promising DM candidates. Due to the Bose enhancement, we find the annihilation rate of the ULDM in the presence of background photon radiation can be greatly enhanced and produce a distinctive reflected electromagnetic wave with an angular frequency equal to the ULDM mass. We propose to utilize such stimulated annihilation to probe the ULDM with the electromagnetic quadratic coupling by emitting a beam of radio into space. With a power of 50 MW emitter, we forecast the sensitivity of quadratic coupling in different local halo models for low-frequency radio telescopes, such as LOFAR, UTR-2 and ngLOBO.

Paper info:

https://journals.aps.org/prd/abstract/10.1103/PhysRevD.109.055026

GW / **26**

A new first-order QCD phase transition in the early universe and gravitational waves

Author: Sichun Sun[1]

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Corresponding Author: sichunssun@gmail.com

We discuss possible ways of extending the Standard Model quantum chromodynamics theory (QCD) theory and realize a first-order phase transition at high temperatures above 1 GeV without running into current constraints from both heavy ion colliders and early cosmology. The phase transition is from a non-perturbative effect of the QCD and can have a great impact on the early universe, including gravitational wave signals detectable for future space interferometers.

Paper info:

Flavor / **27**

QCD axion dark matter and the cosmic dipole problem

Author: Chengcheng Han[1]

[1] *Sun Yat-sen university*

Corresponding Author: hanchengcheng800@gmail.com

TBD

Paper info:

Poster session and dinner / **28**

Dynamic instability analysis for bumblebee black holes: the odd parity

Author: ZHANFENG MAI[1]

Co-authors: Dicong Liang [2]; Lijing Shao [3]; Rui Xu [4]

[1] *Kavli Institute for Astronomy and Astrophysics*, *Peking University*

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Spherical black-hole (BH) solutions have been found in the bumblebee gravity where a vector field nonminimally couples to the Ricci tensor. We study dynamic (in)stability associated with the gravitational and vector perturbations of odd parity against these bumblebee BHs. Under the plane-wave approximation, we find that bumblebee BHs do not suffer ghost instability, but gradient instability and tachyonic instability exist when the bumblebee charge exceeds certain values. The existence of the instabilities also depends on the nonminimal coupling constant ξ that, there is a minimal value $\xi \sim 4\pi G$ with G the gravitational constant for the instabilities to happen.
The theoretical consideration for bumblebee BH stability turns out to place stronger constraints on the parameter space than those from the recent observations of supermassive BH shadows by the Event Horizon Telescope Collaboration. It is also reminiscent of Penrose's cosmic censorship conjecture since the charge of bumblebee BHs cannot be too large due to the dynamic instabilities. Specifically, for $\xi(\xi - 16\pi G) > 0$, we find that the charge of a bumblebee BH cannot be larger than its mass.

Paper info:

arXiv: 2401.07757, accepted by prd

Astrophysics / **29**

Detecting Elastic Coherent Neutrino Scattering with RELICS Experiment

Author: Shengchao Li[1]

[1] 西湖大学 *Westlake University*

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The Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) was predicted in 1974 but wasn't experimentally confirmed until 2017 due to its extremely low energy deposit, making detection challenging due to energy threshold and background levels. Liquid Xenon Time Projection Chambers (LXeTPCs) have shown excellence in dark matter searches and may serve as an ideal technology for detecting CEvNS. The RELICS experiment aims to utilize LXeTPC to detect reactor neutrinos via CEvNS. This report will cover the latest advancements in CEvNS detection.

Paper info:

Flavor / **30**

On the SM quark/lepton masses in an SU(8) theory

Author: ning chen[1]

[1] *Nankai University*

Corresponding Author: chenning_symmetry@nankai.edu.cn

We describe the SM quark/lepton masses in an SU(8) theory, where three-generational SM fermions are non-trivially embedded. A set of d=5 operators that break the emergent global symmetries in the chiral fermion sector due to the Planck scale effects are sufficient to generate the light SM quark/lepton masses as well as the CKM mixing pattern, with one single SM Higgs doublet in the spectrum.

Paper info:

Astrophysics / **32**

Testing ultralight scalar field dark matter in high-redshift universe

Author: Bohua Li[1]

[1] *Guangxi University*

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Scalar field dark matter (SFDM) comprised of ultralight (m ~ 10^{-22} eV) bosonic particles has received significant attention as a viable alternative to Cold Dark Matter (CDM), as it approximates CDM on large scales (⊠ 1 Mpc) while potentially resolving some of its small-scale problems via kpc-scale quantum interference. However, the basic SFDM model described by a free real field, a.k.a. fuzzy dark matter (FDM), is recently challenged by a catch-22 problem: small boson masses yield the desired cores of dwarf galaxies but underpredict structure in the Lyman-α forest, whereas large boson masses render FDM effectively identical to CDM. Therefore, we propose to study the complex SFDM model with a possible self-interaction. A complex scalar field with U(1) symmetry results in the conservation of the associated Noether current, a new degree of freedom. We examine the dynamical implications of the Noether charge for large-scale structure and the Cosmic Microwave Background. We also discuss potential tests of SFDM by the 21cm line from the Cosmic Dawn and by the gravitational-wave (GW) signal from spinning black holes. Furthermore, we demonstrate that the kination phase resulted from complex SFDM can amplify the primordial GW background and thus explain the recent pulsar timing array results.

Paper info:

Flavor / **33**

B meson anomalies and large $B^+ \to K^+\nu\bar{\nu}$ in non-universal $U(1)'$ models

Author: CRISTIAN FELIPE SIERRA FONSECA[1]

Co-authors: Peter Athron [1]; Roberto Martinez [2]

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In view of both the latest LHCb measurement of $R_{K^{(*)}}$ and the new 2.7σ deviation reported by Belle II on $B^+ \to K^+\nu\bar{\nu}$ decays, we present a fit to the B meson anomalies for various one and two dimensional hypothesis including complex Wilson coefficients. We show in a model-independent way that the generic non-universal $U(1)'$ extensions of the SM, without flavour violation, fail to simultaneously fit those observables and corroborate that they can modify $\mathrm{BR}(B^+ \to K^+\nu\bar{\nu})$ up to only a 10%. In view of this deficit, we propose a new way in which those models can accommodate the data at tree level by introducing lepton flavour violating couplings and non-diagonal elements of the charged lepton mixing matrix, with implications in future charged lepton flavour violation searches.

Paper info:

JHEP 02 (2024) 121 • e-Print: 2308.13426 [hep-ph]

DM / **34**

Probe Strongly Coupled Dark Sector via Gravitational Wave

Author: Zhi-Wei Wang[1]

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We go beyond the state-of-the-art by combining first principal lattice results and effective field theory approaches as Polyakov Loop model to explore the non-perturbative dark deconfinement-confinement phase transition and the generation of gravitational-waves in a dark Yang-Mills theory. We further include fermions with different representations in the dark sector. Employing the Polyakov-Nambu-Jona-Lasinio (PNJL) model, we discover that the relevant gravitational wave signatures are highly dependent on the various representations. We also find a remarkable interplay between the deconfinement-confinement and chiral phase transitions. In both scenarios, the future Big Bang Observer and DECIGO experiment have a higher chance to detect the gravitational wave signals. Most recently, via Quark-Meson model, we find the phase transition and thus gravitational wave signals will be significantly enhanced when the system is near conformal. In addition, we find that this effective field theory approach can be implemented to study the glueball dark matter production mechanism and for the first time provide a solid prediction of glueball dark matter abundance. Our prediction is an order of magnitude smaller than the existing glueball abundance results in the literature.

Paper info:

DM / 35

暗 SU(2) 下的矢量玻色子暗物质模型的一些较为一般的讨论

Author: Yi-Lei Tang[1]

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本报告将讨论 SU(2) 矢量暗物质模型中拉矢量的一般构造方式，最终保证暗物质稳定性离散群的一般破缺方式，以及标量粒子的简并模式。

Paper info:

Flavor / 36

Recent $B^+ \to K^+\nu\bar{\nu}$ excess at Belle II, (dark) SMEFT, and flavour structure

Author: 袁兴博 N[one]

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Recently, the Belle II collaboration announced the first measurement of $\mathcal{B}(B^+ \to K^+\nu\bar{\nu})$, which is found to be about 2.7σ higher than the SM prediction. We decipher the data with two new physics scenarios: the underlying $b \to s\nu\bar{\nu}$ transition is, besides the SM contribution, further affected by heavy new mediators that are much heavier than the EW scale, or amended by an additional decay channel with undetected light final states like dark matter or axion-like particles. These two scenarios can be most conveniently analyzed in the SMEFT and the dark SMEFT (DSMEFT) framework, respectively. We consider the flavour structures of the resulting effective operators to be either generic or satisfy the minimal flavour violation (MFV) hypothesis, both for the quark and lepton sectors.

Paper info:

Neutrino / 38

Double-Weak Decays in the PandaX-4T Experiment

Author: 少博王 [1]

[1] *Shanghai Jiao Tong University*

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The possible Majorana nature of Neutrino is crucial for addressing profound questions such as the conservation of lepton number and the origins of the matter-antimatter asymmetry in the universe. Experimentally searching for Majorana neutrinos is one of the most important fields in the forefront of fundamental physics. The PandaX-4T detector, located in the China Jinping Underground Laboratory (CJPL), provides unique opportunities and high-quality data for this type of research through the double-week decays of Xe-136, Xe-134 and Xe-124. We will report the results and the progress of the double-week decay searches.

Paper info:

Phys.Rev.Lett. 132 (2024) 15, 152502 ;

Poster session and dinner / **39**

Wide Binary Evaporation by Dark Solitons

Author: Zihang Wang[1]

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We perform an analytic calculation of binary star evaporation rate under the gravitational potential from spatially extended dark solitons, and demonstrate that Milky Way' s wide binary star systems are susceptible to tidal perturbations from dark matter solitons of comparable and larger sizes. The GAIA data shows a sharp decrease of halo-like wide binaries at large separations, indicating possible disruptions by dark solitons. We further put constraints on the mass and radius of solitons, which may correspond to ultralight bosonic dark matter around $10^{-15}\,\mathrm{eV}$.

Paper info:

Neutrino / **40**

Towards a systematic study of non-thermal leptogenesis from inflaton decays

Author: Xinyi Zhang[1]

[1] *Hebei University*

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We investigates non-thermal leptogenesis from inflaton decays in the minimal extension of the canonical type-I seesaw model, where a complex singlet scalar ϕ is introduced to generate the Majorana masses of right-handed neutrinos (RHNs) and to play the role of inflaton. We systematically study non-thermal leptogenesis with the least model dependence. We give a general classification of the parameter space and find four characteristic limits by carefully examining the interplay between inflaton decay into RHNs and the decay of RHNs into the standard-model particles. We find that the strongly non-thermal RHNs scenario occupies a large parameter space, including the oscillation-preferred K range, and works well for a relatively-low reheating temperature $T_{\rm RH} \geq 10^3$ GeV, extending the lower bound on the RHN mass to 2×10^7 GeV.
We demonstrate that such a unified picture for inflation, neutrino masses, and baryon number asymmetry can be realized by either a Coleman-Weinberg potential or a natural inflation potential for the inflaton. We find that non-thermal leptogenesis from inflaton decay offers a testable framework for the early Universe. The model-independent investigation of non-thermal leptogenesis should be useful in exploring this direction.

Paper info:

2311.05824, accepted for publication in JHEP

Poster session and dinner / **41**

Axion star condensation around primordial black holes and microlensing limits

Authors: Luca Visinelli[1]; 孜文尹 [2]

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Dark matter is one of the biggest mysteries in physics and astronomy today. While multiple dark matter candidates have been proposed, such as the axion and primordial black holes (PBHs), the interplay between them is not well understood. In this talk, I will focus on the formation of axion minihalos around PBHs and the condensation of axion stars inside them, and reveal distinct morphological characteristics of these structures compared to isolated axion star scenarios. Furthermore, I will explore the implications of these results when applied to gravitational microlensing from extended objects, providing constraints on the fraction of these objects contributing to microlensing events from the EROS-2 survey.

Paper info:

Experiments / **42**

Search for T-odd mechanisms beyond the standard model in transversely polarized pe⃗ elastic scattering?

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Within the standard model, transverse single spin asymmetries in electron elastic scatterings can only arise from multi-photon exchanges. The A4@MAMI collaboration has measured the beam transverse single spin asymmetry in electron-proton elastic scattering from 315 to 1508 MeV (Phys. Rev. Lett. 124, 122003 (2020)). The data are significantly different from theoretical calculations based on chiral perturbation (Phys. Rev. C 70, 054003 (2004)), unitarity (Phys. Rev. C 70, 045206 (2004)) and optical theorem (Phys. Rev. C 73, 055201 (2006)). Comparing with the unitary calculation, one may attribute the discrepancy to heavier intermediate states in two-photon exchanges (TPE) which are not included in the calculation. On the other hand, it requires the virtual photon to have large energy to excite high-energy/heavy states, one would expect contributions due to these intermediate states are small. From this point of view, the discrepancy is puzzling. Similar discrepancies were also observed at other laboratories, in both electron-proton and electron-lead scatterings, such as SAMPLE at MIT-Bates (Phys. Rev. C 63, 064001 (2001)), Qweak at JLab (Phys. Rev. Lett. 125 112502 (2020)) and PREX-II at JLab (Phys. Rev. Lett. 128, 142501 (2022)).

Another possible origin of these discrepancies could be T-odd mechanisms beyond the standard model, such as a novel T-violating interaction or an unanticipated two-boson exchange involving one virtual photon and one unknown T-conserving boson. However, the hadronic/nuclear uncertainties (such as possible intermediate states in TPE) in the theoretical calculations hamper us from investigating new physics via the transverse single spin asymmetry. In view of this, we propose to measure the transverse spin asymmetry in proton-electron (pe⃗) scattering instead of electron-proton (e⃗ p) scattering using an unpolarized proton beam and polarized electrons in a polarized hydrogen gas target, which is planned at the hadronic accelerator HIAF, currently under construction at IMP, CAS. In pe scatterings, the effective energy (or Q2) is 2~3 orders smaller than in ep scattering, only elastic intermediate state (i.e., proton) will be involved in two-photon exchanges. As a result, theory based on unitarity can provide calculations with little theoretical uncertainties. In experiments with polarized electron beams, asymmetries are usually very small due to relativistic effects. In scatterings between an unpolarized proton beam and a polarized electron target, no such

effects present, as a result, the asymmetry will be larger by 4 orders, compared with e⃗ p experiments with electron beams of 1~2 GeV. Consequently, systematical errors in the experiment will be reduced significantly. Given the above advantages, the transversely polarized pe⃗ scattering could be an attractive approach to search for new physics.

Paper info:

DM / 43

Levitodynamics with multi-stochastic forces and the simple applications on the dark matter detection

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If the terrestrial environment is permeated by dark matter, the levitation experiences damping forces and fluctuations attributed to dark matter. This paper investigates levitodynamics with multiple stochastic forces, including thermal drag, photon recoil, feedback, etc., assuming that all of these forces adhere to the fluctuation-dissipation theorem. The ratio of total damping to the stochastic damping coefficient distinguishes the levitodynamics from cases involving only one single stochastic force. The heating and cooling processes are formulated to determine the limits of temperature change. All sources of stochastic forces are comprehensively examined, revealing that dark matter collisions cannot be treated analogously to fluid dynamics. Additionally, a meticulous analysis is presented, elucidating the intricate relationship between the fundamental transfer cross-section and the macroscopic transfer cross-section. While the dark damping coefficient is suppressed by the mass of the levitated particle, scattering can be coherently enhanced based on the amount of the component microscopic particle, the nucleus form factor, and the static structure factor. Hence, dark damping holds the potential to provide valuable insights into the detection of the macroscopic strength of fundamental particles. We propose experimental procedures for levitation and employ linear estimation to extract the dark damping coefficient. Utilizing current levitation results, we demonstrate that the fundamental transfer cross section of dark matter can be of the order σ_T^{D} $lsimcalO(10^{-26})\mathrm{cm}^2$

Paper info:

Astrophysics / 44

Baryon overproduction constraints on the lepton flavor asymmetry in the early Universe

Author: Kohei Kamada[1]

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Anomalous transport phenomena, such as the chiral magnetic effect, are originated from the chiral anomaly of gauge theories and recently developed in hadron and condensed matter physics. They can also cause interesting phenomena in the early Universe when the chirality is a good conserved quantity at the temperature much higher than 100 TeV. An example is the chiral plasma instability, where helical hypermagnetic fields are amplified from chiral asymmetry, which will be the source of the baryon asymmetry through the hypermagnetic helicity decay. In particular, we point out that a large lepton flavor asymmetry before the electroweak symmetry breaking with satisfying total

B-L to be zero, which has been thought not to be strongly constrained, generally corresponds to a large chiral asymmetry. This causes an amplification of a strong helical magnetic field, which leads to baryon overproduction. We find that this gives a stronger constraint on the lepton flavor asymmetry than the one given weakly from the BBN. In a similar way that a large lepton asymmetry before the electroweak symmetry breaking is constrained by the SU(2) electroweak sphalerons/chiral anomaly to avoid the baryon overproduction, we conclude that a large lepton flavor asymmetry is constrained by the U(1) hypergauge chiral anomaly.

Paper info:

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.130.261803

Poster session and dinner / **45**

Future targets for light gauge bosons from cosmic strings

Authors: Hanyu Cheng[1]; Luca Visinelli[2]

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Cosmic strings, theoretical one-dimensional topological defects from the early universe, are a compelling source for studying dark matter production and gravitational wave (GW) emission. In this talk, I will focus on the production of gauge bosons and GW emission resulting from the decay of cosmic strings, discussing the constraints imposed by cosmological considerations. Specifically, I will examine the contribution of gauge bosons radiated from strings to dark matter and dark radiation respectively, which are strictly limited by the observed dark matter abundance and Cosmic Microwave Background data respectively. Moreover, I will assess the GW spectrum of this model against the forecasted capabilities of future GW observatories, with a particular emphasis on the Laser Interferometer Space Antenna. Following that, I will provide an overview of how these considerations influence the model parameters, specifically the gauge boson mass and the energy scale of U(1) symmetry breaking, offering insights into the potential for cosmic strings to inform our understanding of dark matter and GW astronomy.

Paper info:

Astrophysics / **46**

Extreme mass ratio inspirals in evolving nuclear star clusters

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Recently we have build a Monte-Carlo method that can obtain self-consistent solutions of an evolving nuclear star cluster that contains a central massive black hole. Our method evolves the orbits of stellar objects by solving two-dimensional (energy and angular momentum) Fokker-Planck equations given multiple mass components. In this study we apply our method to investigate the evolution of the rates of extreme mass ratio inspirals over cosmic time.

Paper info:

Poster session and dinner / **47**

Weak Lensing Constraints on Dark Matter-Baryon Interactions with N-Body Simulations and Machine Learning

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We investigate the elastic scattering cross section between dark matter and protons using the DES Year 3 weak lensing data. This scattering induces a dark acoustic oscillation structure in the matter power spectra. To address non-linear effects at low redshift, we utilize principal component analysis alongside a limited set of N-body simulations, improving the reliability of our matter power spectrum prediction. We further perform a robust Markov Chain Monte Carlo analysis to derive the upper bounds on the DM-proton elastic scattering cross-section, assuming different velocity dependencies. Our results, presented as the first Frequentist upper limits, are compared with the ones obtained by Bayesian approach. Compared with the upper limits derived from the Planck cosmic microwave background data, our findings from DES Year 3 data exhibit improvements of up to a factor of five. In addition, we forecast the future sensitivities of the China Space Station Telescope, the upcoming capabilities of this telescope could improve the current limits by approximately one order of magnitude.

Paper info:

Poster session and dinner / **49**

Searching for heavy neutral lepton and LNV through VBS at muon colliders

Authors: Tong Li[1]; Changyuan Yao[2]; Man Yuan[1]

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High-energy muon collider can play as an emitter of electroweak gauge bosons and thus leads to substantial vector boson scattering (VBS) processes. In this work, we investigate the production of heavy neutral lepton (HNL) N and lepton number violation (LNV) signature through VBS at high-energy muon colliders. They provide clean and robust LNV signatures to tell the nature of Majorana HNLs and thus have more advantageous benefits than direct $\mu\mu$ annihilation. We analyze the potential of searching for Majorana HNL and obtain the exclusion limits on mixing $V_{\ell N}$. Based on this same-sign lepton signature, we also obtain the sensitivity of muon collider to the Weinberg operator.

Paper info:

JHEP 09 (2023) 131 (https://arxiv.org/abs/2306.17368)

Poster session and dinner / **50**

Neutron star cooling with lepton-flavor-violating axions

Authors: Andrew LongN[one]; Hong-Yi ZhangN[one]; Ray HagimotoN[one]

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The cores of dense stars are a powerful laboratory for studying feebly-coupled particles such as axions. Some of the strongest constraints on axionlike particles and their couplings to ordinary matter derive from considerations of stellar axion emission. In this work we study the radiation of axionlike particles from degenerate neutron star matter via a lepton-flavor-violating coupling that leads to muon-electron conversion when an axion is emitted. We calculate the axion emission rate per unit volume (emissivity) and by comparing with the rate of neutrino emission, we infer upper limits on the lepton-flavor-violating coupling $|g_{ae\mu}|$ that are at the level of 10^{-6}. For the hotter environment of a supernova, such as SN 1987A, the axion emission rate is enhanced and the limit is stronger, at the level of 10^{-11}, competitive with laboratory limits. Interestingly, our derivation of the axion emissivity reveals that axion emission via the lepton-flavor-violating coupling is suppressed relative to the familiar lepton-flavor-preserving channels by the square of the plasma temperature to muon mass ratio, which is responsible for the relatively weaker limits.

Paper info:

Poster session and dinner / **51**

A mechanism relating the fermionic mass hierarchy to the flavor mixing

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Considering the hierarchical structure of fermionic masses and the fermionic flavor mixing puzzles in the Standard Model, we propose to relate them by the see-saw mechanism, i.e. only the third generation of quarks and charged leptons achieve the masses at the tree level, the first two generations achieves masses through the mixings with the third generation, and the neutrinos achieve tiny Majorana masses by the so-called Type-I see-saw mechanism. This new picture at the fermion sector can explain simultaneously the flavor mixing puzzle and mass hierarchy puzzle in the SM. In addition, a flavor-dependent model (FDM) is proposed to realize the new mechanism, and observing the top quark rare decay processes $t \to ch$, $t \to uh$ and the lepton flavor violation processes $\mu \to 3e,\ \tau \to 3e,\ \mu \to 3\mu$ is effective to test the proposed FDM.

Paper info:

Astrophysics / **52**

Primordial black holes from slow phase transitions: a model-building perspective

Author: Masanori Tanaka[1]

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We discuss the relation between the Higgs potential structure and primordial black hole (PBH) formations. Recently, it has been discussed that PBHs can be formed by first-order phase transitions at the early Universe. In this talk, we consider the PBH formation mechanism through delayed first-order phase transitions at the early Universe. If the phase transition is delayed, the large energy density fluctuation can be realized between symmetry broken and unbroken regions. If the density fluctuation can be larger than a certain criterion, the overdensity region may collapse to PBHs. We discuss the form of the Higgs potential needed to realize this PBH formation. In addition, we show that the commonly used exponential approximation of the bubble nucleation rate fails to capture such PBH formation.

Paper info:

https://inspirehep.net/literature/2772958

Poster session and dinner / **54**

The electroweak magnetic monopole in the presence of KSVZ axion

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The Witten effect implies the dynamics of axion and magnetic monopole. The Cho-Maison monopole is a realistic electroweak monopole arisen in the Weinberg-Salam theory. This monopole of TeV scale mass motivates the dedicated search for electroweak monopole at colliders. In this work we investigate the implication of KSVZ axion to the electroweak magnetic monopole. We use the spherically symmetric ansatz for the electroweak dyon and introduce the spherically symmetric function for the axion field. The effective Lagrangian is then shown in terms of the electroweak monopole part, the axion kinetic energy as well as the axion interaction term. We derive the consequent equations of motion in the presence of the axion-photon coupling and show the numerical results of the topological solutions. We then calculate the changed characteristics of the electroweak monopole such as the monopole mass and the electromagnetic charges, as well as the axion potential energy.

Paper info:

Poster session and dinner / **55**

Cosmologically Consistent Analysis of Gravitational Waves from Hidden Sectors under Synchronous Thermal Evolution

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In this talk, we will discuss production of gravitational waves in the early universe within a first order phase transition involving a hidden sector feebly coupled with the visible sector. Unlike most existing studies on GWs from hidden sectors, which assume a constant temperature ratio between the hidden and visible sectors (i.e., ξ=T_h/T=const), we adopt a more precise approach using synchronous thermal evolution, denoted as ξ(T). We will discuss in detail how to obtain this ξ(T) and how it will influence our analysis on GWs from hidden sectors. As a result, we find that the two-field model predicts gravitational waves accessible at several proposed gravitational wave detectors: LISA, DECIGO, BBO, Taiji and their discovery would probe specific regions of the hidden sector parameter space and may also shed light on the nature of bubble nucleation in the early universe.

Paper info:

https://arxiv.org/abs/2403.09558

Experiments / **56**

New physics probed with off-Z-pole data

Authors: Shao-Feng Ge[1]; Zhuoni Qian[2]; Michael Ramsey-MusolfN[one]; Jia ZhouN[one]

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We fully explore the prospect of using the off Z-pole run at
future lepton colliders to probe the new physics (NP) beyond the Standard Model (SM) via dimension-6 four-fermion effective operators. With interference between the dimesion-6 operator and SM diagram contributions to the $e^+e^- \to f\bar{f}$ scattering processes, the NP effects shows up at collision energy
off of the Z pole. The Z line shape scan is thus useful not just for the Z mass and width measurements, but
also for NP probes. I will discuss the key observable and uncertainties involved in order to reach a realistic prospects for the reach.

Paper info:

Neutrino / **57**

SMEFT vs HEFT in the case of type-II seesaw

Authors: Xiao-Dong Ma[1]; Yi Liao[1]; Yoshiki Uchida[1]

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The representative effective field theories(EFTs) written in terms of Standard Model particles are Standard Model EFT(SMEFT) and Higgs EFT(HEFT). When we integrate out the heavy particles in the UV theory before electroweak symmetry breaking, it results in the SMEFT. On the other hand, if we integrate out the heavy particles taking into account the mass mixing in the symmetry-breaking phase, it results in the HEFT. Recently, the matching type-I, II, and III seesaw onto the SMEFT has been studied by the IHEP group and attracted a lot of attention. We have matched the

type-II seesaw model onto the HEFT and compared our results with those of previous studies. We show quantitatively how much more accurate the HEFT description is than the SMEFT when the mass scale of the heavy particles is close to the electroweak scale.

Paper info:

The paper is in preparation.

Astrophysics / **59**

Gravitational waves from the sound of first-order phase transition

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Phase transition gravitational waves could be a novel probe for fundamental physics in the near future. Hence, precise calculation of phase transition gravitational waves is essential to revealing many unresolved puzzles in our universe. I will discuss a framework that could allow us to omit some unnecessary approximations and give a relatively more accurate calculation of gravitational waves generated by the sound wave mechanism. I will use a benchmark model to demonstrate the procedures of this framework and show the corresponding results.

Paper info:

Astrophysics / **60**

Constraining Bosonic Dark Matter-Baryon Interactions from Neutron Star Collapse

Author: Arvind Kumar Mishra[1]

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Dark matter (DM) may be captured around a neutron star (NS) through DM-nucleon interactions. We observe that the enhancement of such capturing is particularly significant when DM-nucleon scattering cross-section depends on the relative velocity and/or momentum transfer. This increment could potentially lead to the formation of a black hole within the typical lifetime of the NS. As the black hole grows through the accretion of matter from the NS, it ultimately results in the collapse of the host. Utilizing the existing pulsar data J0437-4715 and J2124-3858, we derive the stringent constraints on the DM-nucleon scattering cross-section across a broad range of DM masses.

Paper info:

arXiv:2404.07187 [hep-ph]

DM / **61**

Dark matter search results in PandaX-4T experiment

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PandaX-4T experiment is a dark matter direct detection experiment that employs a dual-phase time projection chamber with a sensitive volume containing 3.7 tonnes of liquid xenon. Since 2020, the PandaX-4T experiment has finished the data taking of run0 and run1 which has been used to test several dark matter models. In this talk, we will discuss the latest dark matter search results of the PandaX-4T experiment.

Paper info:

Higgs / **65**

long-lived particle search

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The ForwArd Search ExpeRiment (FASER,), is a recently installed detector at the LHC that can detect light, long lived particles. In this work we study the prospect of detecting light CP-even and CP-odd scalars at the FASER. We develop the general formalism for the scalar production and decay from mesons at LHC, given modified couplings of the scalars to the SM particles, as well as summarizing the relevant GeV-scale experiment constraints. We then analyze the reaches of light scalars in the large $\tan\beta$ region of the Type-I 2HDM, in which a light scalar with relatively long life time could be accommodated.

Paper info:

Poster session and dinner / **66**

Degeneracy Enhancement of Neutron-Antineutron Oscillation in Neutron Star

Authors: Qiheng WangN[one]; Shao-Feng Ge[1]; Xuanye Fu[2]; Ziyang GuoN[one]

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We explore the theoretical description of oscillations in degenerate cases, presenting the formula for oscillation probability with neutrino oscillation as an illustrative example. We then apply the degenerate oscillation theory to study neutron-antineutron oscillations, calculating the constraints of the new model on oscillation parameters, such as mixing angles, in neutron stars. Our findings

provide valuable insights into the behavior of particle oscillations in extremely degenerate environments, offering strong constraints on neutron-antineutron mixing, and further restrict the choice of GUT models.

Paper info:

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Charm Physics at BES III

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Joint Study of Anomalous Magnetic Moment of Muon and Mechanism of Neutrino Mass Generation

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Imprints of Dissipative Effects in Phase Transition Gravitational Waves

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Illuminating Black Hole Shadow with Annihilating Dark Matter

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Spontaneous CP violation in Supersymmetric QCD

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Light Thermal Dark Matter Beyond p-Wave Annihilation in Minimal Higgs Portal Model

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Detecting a Fifth-Force Gauge Boson via Superconducting Josephson Junctions

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A systematic investigation on dark matter-electron scattering in effective field theories

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Discovering axions at muon experiments

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Probing lepton flavour violating ALPs at \muˆ+\muˆ+ and \muˆ+ eˆ- colliders

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Exploring interference effects between two ALP effective operators at the LHC

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Recent results from Belle II

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SRF Cavity Searches for Dark Photon Dark Matter

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BSM physics at ATLAS

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Dynamic Universe: A FAST Perspective

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Binary Neutron Stars: Electromagnetic and Gravitational Wave Binaries, and Kilonovae

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Hunting for wimps and beyond

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Axion-like particle triggered baryogenesis

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Neutrinoless double beta decay in seesaw models

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The origin of pseudo-Nabmu-Goldstone-Boson Dark Matter

Flavor / **94**

Jet origin identification at CEPC

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Flavor / **95**

Outlook for Muon g-2 measurement

Corresponding Author: liangliphy@sjtu.edu.cn

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New perspective of chiral symmetry

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12m kHz GW detector prototype at Beijing Normal University

Astrophysics / **99**

Probing ultralight particles with gravitational waves

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CPTA current status and future expectation

Paper info:

Astrophysics / **101**

Searching for Ultralight New Particles with Spin-Polarized Systems

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The revelation of the nature of the inertial force and its physical impacts