The 4th International BSM Workshop: Building for Tomorrow

Report of Contributions

https://indico-tdli.sjtu.edu.cn/e/4076

Contribution ID: **82** Type: **not specified**

Constraints on L= 2 Vector Bosons with Tree Couplings to SM Leptons

Tuesday, 26 August 2025 13:30 (20 minutes)

We investigate phenomenological implications of vector bosons V transforming as (1, 2, -3/2) under the standard model (SM) product gauge group $SU(3)_C$, $SU(2)_L$ and $U(1)_Y$. These vector bosons can couple to two SM leptons at tree-level forming dimension-4 operators. These operators dictate V to have two units of global lepton number, $\Delta L = 2$. The operators generated conserve the global lepton number but can violate generational lepton numbers. We study constraints on the couplings Y of V to SM particles using tree-level processes such as $l_\alpha^- \to l_\beta^+ l_\rho^- l_\sigma^-$, muonium and antimuonium oscillation, neutrino trident scattering, inverse muon decay, $e^- e^+ \to l^- l^+$, and also one-loop level processes such as the magnetic dipole moment of a charged lepton and $l_i \to l_j \gamma$. Strong constraints are obtained from $l_\alpha^- \to l_\beta^+ l_\rho^- l_\sigma^-$ with $\left|Y_{ee} Y_{\mu e}^*\right| < 3.29 \times 10^{-11} \left(m_V/\mathrm{GeV}\right)^2$, $\left|Y_{ee} Y_{e\mu}^*\right| < 3.29 \times 10^{-11} \left(m_V/\mathrm{GeV}\right)^2$ and from $l_i \to l_j \gamma$ with $\left|Y_{\tau e} Y_{\mu\tau}^*\right| < 3.46 \times 10^{-12} (m_V/\mathrm{GeV})^2$, $\left|Y_{e\tau} Y_{\tau\mu}^*\right| < 3.46 \times 10^{-12} \left(m_V/\mathrm{GeV}\right)^2$, respectively. Interestingly, the imaginary part of the coupling constant in our model induces CP violation, which is constrained by experimental limits on the electric dipole moment.

Primary author: HUANG, Zhonglv (TDLI)

Co-author: Mr HE, Xiao-Gang (TDLI)

Presenter: HUANG, Zhonglv (TDLI)

Session Classification: Parallel talks (2)

Contribution ID: **83** Type: **not specified**

Machine Learning for Parton-Level Studies of Quantum Entanglement Using pp⟶ττ

Tuesday, 26 August 2025 13:50 (20 minutes)

Quantum entanglement is a hallmark feature of quantum mechanics, manifesting as correlations between subsystems that cannot be fully described without one another, regardless of spatial separation. While entanglement has been observed in processes such as $pp \to t\bar{t}$ and thoroughly analyzed in Higgs decay channels ($H \to VV$) at the Large Hadron Collider (LHC), it remains comparatively underexplored in the $pp \to \tau\tau$ system. In this study, we adapt OmniLearn, a foundational model for solving all jet physics tasks, to reconstruct the neutrino information in the final state of $pp \to \tau\tau$ system, which is an essential step toward probing quantum entanglement in this channel. Good neutrino reconstruction has reached now, which is the key to the following steps in the reconstruction level study.

Primary authors: ZHOU, Baihong (TDLI, SJTU); Dr LIU, Qibin (SLAC); LI, Shu (TDLI, SJTU); Dr ZHANG, Yulei (Univ. of Washington)

Presenter: ZHOU, Baihong (TDLI, SJTU)

Session Classification: Parallel talks (2)

Contribution ID: **84** Type: **not specified**

Massive Gauge Theories from Consistency Conditions of Amplitudes

Tuesday, 26 August 2025 16:40 (20 minutes)

Based on the general principles of Lorentz symmetry and unitary, we introduce two consistency conditions – on-shell gauge symmetry and strong massive-massless continuation – in constructing amplitudes of massive gauge theory with elementary particles. Combined with the little group transformation and consistent factorization, we construct 3-point and 4-point vector boson/scalar amplitudes under these conditions. Given the particle masses, almost all possible vertices, including those involving Goldstone modes, are uniquely fixed. The only exceptions are triple and quartic scalar self-couplings. We also discuss different underlying models behind particles are assigned different masses. Our main conclusion is that the only theories that can be constructed under the proposed conditions are either theories with spontaneous symmetry breaking(both abelian and non-abelian) or Stueckelberg theory (only abelian).

Primary author: Prof. CHEN, Junmou (Jinan University)

Presenter: Prof. CHEN, Junmou (Jinan University)

Session Classification: Parallel talks (2)

Contribution ID: **85** Type: **not specified**

Applications of non-invertible selection rules to flavor physics

Wednesday, 27 August 2025 10:00 (30 minutes)

Selection rules are fundamental principles in quantum systems and quantum field theory, determining whether certain couplings are allowed or forbidden. Conventionally, selection rules are associated with conservation laws originating from a certain group-like symmetry. However, it has been found that non-invertible selection rules also appear in quantum field theory and string theory. In this talk, I will discuss an application of non-invertible selection rules, derived from a fusion algebra, to particle physics, specifically, the flavor structure of quarks and leptons [1,2,3]. I will also introduce such non-invertible selection rules in type II intersecting/magnetized D-brane models [4] and heterotic string theory on Calabi–Yau threefolds [5].

References:
[1] T. Kobayashi, H. Otsuka and M. Tanimoto, Yukawa textures from non-invertible symmetries, JHEP 12 (2024) 117.
[2] T. Kobayashi, Y. Nishioka, H. Otsuka and M. Tanimoto, More about quark Yukawa textures from selection rules without group actions, JHEP 05 (2025) 177.
[3] T. Kobayashi, H. Okada, and H. Otsuka, Radiative neutrino mass models from non-invertible selection rules, 2505.14878 [hep-ph].
[4] T. Kobayashi and H. Otsuka, Non-invertible flavor symmetries in magnetized extra dimensions, JHEP 11 (2024), 120.
[5] J. Dong, T. Kobayashi, R. Nishida, S. Nishimura and H. Otsuka, Coupling Selection Rules in Heterotic Calabi-Yau Compactifications, 2504.09773 [hep-th].

Primary author: OTSUKA, Hajime (Kyushu University)

Presenter: OTSUKA, Hajime (Kyushu University)

Session Classification: Plenary talks (3)

Contribution ID: **86** Type: **not specified**

One-loop analysis of dark matter constraints in a complex scalar extension of the Standard Model

We investigate the complex singlet extension of the Standard Model, which provides a pseudo-Nambu-Goldstone dark matter candidate. In addition to the latest and most stringent bounds from dark matter direct detection experiment, we impose the observed DM relic abundance and a novel condition that the imaginary component of the singlet field does not develop a vacuum expectation value, ensuring its stability as dark matter. We perform a full one-loop analysis of the effective potential, including counterterm contributions, and examine their impact on the allowed parameter space. Our results reveal that viable regions still exist, some of which appear only when counterterms are properly included, highlighting the importance of quantum corrections and the vacuum structure in precision dark matter studies.

Primary authors: IDEGAWA, Chikako (Sun Yat-sen University); Prof. FUNAKUBO, Koichi (Saga University)

Presenter: IDEGAWA, Chikako (Sun Yat-sen University)

Session Classification: Parallel talks (2)

Contribution ID: **87** Type: **not specified**

Multi-axion dynamics and a new resolution of the QCD domain wall problem

Monday, 25 August 2025 09:00 (30 minutes)

We study the evolution of topological defects in multi-axion models and propose a novel solution to the domain wall problem of the QCD axion.

Multi-axion dynamics, arising from multiple Peccei–Quinn scalars, can lead to qualitatively different defect evolution compared to single-axion models. In particular, networks of cosmic strings and high-tension domain walls tend to form, posing a serious cosmological problem even when the low-energy theory appears to contain only a single axion field.

Applying this finding to the QCD axion, we show that introducing an additional massless or light axion that couples to gluons can resolve the notorious domain wall problem of the QCD axion. In one scenario, the new axion forms strings, and its mixing with the QCD axion confines domain walls into stable string bundles. These bundles may survive until today and generate observable signatures such as gravitational waves, cosmic birefringence, or CMB anisotropies.

Primary author: Prof. TAKAHASHI, Fuminobu (Tohoku University)

Presenter: Prof. TAKAHASHI, Fuminobu (Tohoku University)

Session Classification: Plenary talks (1)

Contribution ID: **88** Type: **not specified**

Electroweak Precision Data as a Gateway to Light Higgsinos

Tuesday, 26 August 2025 11:30 (30 minutes)

We investigate the prospects of probing weak-scale higgsinos through electroweak precision measurements at a future e^+e^- collider. In the Minimal Supersymmetric Standard Model, higgsinos mix with winos and binos after electroweak symmetry breaking, forming charginos and neutralinos. These states contribute to electroweak precision observables, which can be measured with high accuracy at future e^+e^- colliders. Their contributions depend on the mixing structure, as evidenced by the generation of the oblique parameters S and T, in addition to the W and Y parameters, which arise even in the absence of mixing. We demonstrate that higgsinos with masses up to ~ 500 GeV can be probed through future electroweak precision experiments, highlighting their significance in probing weak-scale supersymmetry.

Primary author: NAGATA, Natsumi

Presenter: NAGATA, Natsumi

Session Classification: Plenary talks (2)

Contribution ID: **89** Type: **not specified**

A triple Z' signal via light scalar boson in Z-factories

Tuesday, 26 August 2025 14:10 (20 minutes)

In this talk, we discuss triple Z' boson signals via the decay chain of $Z \to Z'\phi \to Z'Z'Z'$, with a new light scalar ϕ, at future Z factories such as CEPC and FCC-ee. These new bosons ϕ and Z' naturally appear in models with a new $U(1)$ gauge symmetry which is spontaneously broken and introduced in various new physics scenarios. The branching ratio of $Z \to Z'\phi \to Z'Z'Z'$ can be larger than 10^{-12}, which gives $O(1)$ events at Tera-Z experiments, when a product of g_X (new gauge coupling) and ζ (Z-Z' mixing) is larger than around 10^{-6}. We find that the search for $Z \to Z'Z'Z'$ can significantly improve the current bound on a kinetic mixing parameter ϵ in the dark photon case, where $e\epsilon$ larger than $\mathcal{O}(10^{-5})$ with $g_X = calO(1)$ can be explored at Tera-Z experiments.

Primary authors: NOMURA, Takaaki (Sichuan University); Prof. YAGYU, Kei (Tokyo University of Science)

Presenter: NOMURA, Takaaki (Sichuan University)

Session Classification: Parallel talks (2)

Contribution ID: **90** Type: **not specified**

Scattering Entanglement Entropy and Its Implications for Electroweak Phase Transitions

Wednesday, 27 August 2025 09:30 (30 minutes)

In this presentation, we discuss a relation between the dynamics of the ElectroWeak Phase Transition (EWPT) and the entanglement entropy defined in scattering processes. As a representative scenario, we focus on the SM extension with N singlet scalar fields with the global O(N) symmetry. We also discuss a possibility that the entanglement entropy may be used as an order parameter for the EWPT. The content of this talk is based on the following paper [https://arxiv.org/abs/2505.06001].

Primary author: TANAKA, Masanori (Peking University)

Co-authors: LIU, Jia (Peking University); Mr ZHANG, Jing-Jun (Peking University); WANG, Xiaoping (Beihang University); Mr ZHENG, Zifan (Peking University)

Presenter: TANAKA, Masanori (Peking University)

Session Classification: Plenary talks (3)

Contribution ID: **91** Type: **not specified**

Bell Inequality Violation of Light Quarks in Dihadron Pair Production at Lepton Colliders

Spin correlations between particles produced at colliders provide valuable insights for quantum information studies. While traditional studies of quantum information at colliders are typically limited to massive particles with perturbative decay, we propose an innovative method to explore the Bell inequality in massless quark pair systems by analyzing the azimuthal correlations in $\pi^+\pi^-$ dihadron pair production at lepton colliders. Revisiting the Belle data, we have shown the potential to detect Bell inequality violation of light quarks by introducing an additional angular cut, achieving a significance of 2.5 σ even in the worst-case scenario of 100\% correlated systematic uncertainties in each bins. The significance substantially exceeds 5σ when considering uncorrelated systematic uncertainties. Our approach opens avenues for exploring spin quantum information with non-perturbative processes as spin analyzer and leverages existing data for quantum information research.

Primary author: Prof. YAN, Bin (IHEP)

Presenter: Prof. YAN, Bin (IHEP)

Session Classification: Parallel talks (2)

Contribution ID: **93** Type: **not specified**

Probing ultralight dark matter in the wilderness

Monday, 25 August 2025 13:30 (20 minutes)

The interplay between wave-like dark matter and Earth ' s conductive properties generates a global monochromatic magnetic field. Simple experimental setups, such as those pioneered by the SNIPE Hunt collaboration, have already demonstrated the feasibility of probing axion-like particles and dark photons. Beyond these candidates, this approach can also be extended to ultralight dark matter carrying a tiny electric charge. In this talk, I will discuss how such magnetic field signals arise for all three dark matter scenarios and present the current experimental status, along with future detection prospects.

Primary author: ARZA, Ariel (Nanjing Normal University)

Presenter: ARZA, Ariel (Nanjing Normal University)

Session Classification: Parallel talks (1)

Contribution ID: **94** Type: **not specified**

Dark Bondi Accretion Aided by Baryons and the Origin of JWST Little Red Dots

Tuesday, 26 August 2025 15:40 (20 minutes)

The gravothermal core collapse of self-interacting dark matter halos provides a compelling mechanism for seeding supermassive black holes in the early Universe. In this scenario, a small fraction of a halo, approximately 1% of its mass, collapses into a dense core, which could further evolve into a black hole. We demonstrate that this process can account for the origin of JWST little red dots (LRDs) observed at redshifts $z \sim 4$–11, where black holes with masses of $10^7\,\mathrm{M}_\odot$ can form within $500\,\mathrm{Myr}$ after the formation of host halos with masses of $10^9\,\mathrm{M}_\odot$. Even if the initial collapse region triggering general-relativistic instability has a mass on the order of one solar mass, the resulting seed can grow into an intermediate-mass black hole via Eddington accretion of baryonic gas. Subsequently, it can continue to grow into a supermassive black hole through dark Bondi accretion of dark matter particles. In this scenario, the majority of the black hole's mass originates from dark matter accretion rather than baryonic matter, naturally explaining the overmassive feature of LRDs.

Primary author: FENG, Wei-Xiang

Presenter: FENG, Wei-Xiang

Session Classification: Parallel talks (2)

Contribution ID: **95** Type: **not specified**

The electroweak precision constraints of the 2HDM+S

Tuesday, 26 August 2025 16:00 (20 minutes)

The 2HDM+S is the singlet extension of the Two-Higgs-Doublets Model (2HDM). The singlet field and its mixing with the 2HDM Higgs sector lead to new contributions to the electroweak precision observables, in particular, the oblique parameters. In this paper, we identify five benchmark cases, where at most one mixing angle is nonzero and analyze the 95\% C.L. allowed parameter space by the oblique parameters. In the alignment limit of the 2HDM, we find that other than the usual mass relations of $m_H \sim m_{H^\pm}$ or $m_A \sim m_{H^\pm}$, electroweak precision measurements also impose an upper limit on the neutral Higgs masses. In the cases with nonzero singlet mixing with the 2HDM Higgses H or A, we find approximate mass relations of $c^2_{\alpha_{HS}} m_H + s^2_{\alpha_{HS}} m_{h_S} = m_{H^\pm}$ or $c^2_{\alpha_{AS}} m_A + s^2_{\alpha_{AS}} m_{A_S} = m_{H^\pm}$. Those relations are universal to the 2HDM+S models, with or without further symmetry assumption. We also study the non-alignment limit of the 2HDM+S, which typically has tighter constraints on the masses and mixing angles. At the end, we examine the complementarity between the electroweak precision analyses and the Higgs coupling precision measurements.

Primary authors: LI, Cheng (Sun-Yat-Sen University); LI, Juxiang; SU, Shufang; SU, Wei (SYSU)

Presenter: LI, Cheng (Sun-Yat-Sen University)

Session Classification: Parallel talks (2)

Contribution ID: **96** Type: **not specified**

Little Red Dots from Small-Scale Primordial Black Hole Clustering

Monday, 25 August 2025 13:50 (20 minutes)

The James Webb Space Telescope (JWST) observations have identified a class of compact galaxies at high redshifts (4 \lesssim z \lesssim 11), dubbed “little red dots” (LRDs). The supermassive black holes (SMBHs) of 10^{5-8}{\rm\,M}_{\odot} in LRDs favor a heavy-seed origin. We propose a mechanism for their formation: Clusters of primordial black holes, formed through long-short mode coupling on small scales in the early Universe, undergo sequential mergers over extended timescales. This mechanism can evade cosmic microwave background distortions and result in heavy-seed SMBHs via runaway mergers. We employ Monte Carlo simulations to solve the Smoluchowski coagulation equation and determine the runaway merging timescale. The resulting stochastic gravitational wave background offers a distinct signature of this process, and the forming SMBHs can be highly spinning at their formation due to the spin residual of the cluster from tidal fields. This mechanism may explain the rapidly spinning SMBHs in LRDs under the assumption of obscured active galactic nuclei.

Primary author: Mr ZHANG, Borui (Tsinghua University)

Co-authors: Mr AN, Haipeng (Tsinghua University); Mr FENG, Weixiang (Tsinghua University)

Presenter: Mr ZHANG, Borui (Tsinghua University)

Session Classification: Parallel talks (1)

Contribution ID: **97** Type: **not specified**

Long lived Particle searches of Higgs sector

Monday, 25 August 2025 14:10 (20 minutes)

TBD

Primary author: SU, Wei (SYSU)

Presenter: SU, Wei (SYSU)

Session Classification: Parallel talks (1)

Contribution ID: **99** Type: **not specified**

Interplay of ALP Couplings at a Muon Collider

Tuesday, 26 August 2025 14:30 (20 minutes)

Axion-like particles can couple to Standard Model gluons, electroweak gauge bosons, and massive fermions. A future multi-TeV muon collider provides a favorable environment to probe axion-like particles through multiple production channels, including vector boson fusion via electroweak gauge boson couplings and the top-associated production mediated by direct fermionic couplings. Motivated by the quality issue of the QCD axion, we focus on axion-like particles with masses and decay constants around the TeV scale. We explore how different axion-like particle couplings shape its production and decay modes, revealing a rich and intricate phenomenological landscape.

Primary authors: Dr CHIGUSA, So; GIRMOHANTA, Sudhakantha (Tsung-Dao Lee Institute and Shanghai Jiao Tong University); ZHANG, Yufei; NAKAI, Yuichiro

Presenter: ZHANG, Yufei

Session Classification: Parallel talks (2)

Contribution ID: **100** Type: **not specified**

Small Instantons and the Post-Inflationary QCD Axion in a Special Product GUT

Tuesday, 26 August 2025 16:20 (20 minutes)

We present a new framework of grand unification that is equipped with an axion solution to the strong CP problem without a domain wall problem when the Peccei–Quinn (PQ) symmetry is spontaneously broken after inflation. Our grand unified theory (GUT) is based on a symmetry breaking pattern, SU(10) ×SU(5)1 ⟶SU(5)V ⊃SU(3)C ×SU(2)L ×U(1)Y, where SU(5)1 and a special embedding of SU(5)2 ⊂SU(10) are broken to a diagonal subgroup SU(5)V. The model contains a vector-like pair of PQ-charged fermions that transform as (anti-)fundamental representations under SU(10), so that the domain wall number is one. However, after the GUT symmetry breaking, the number of vector-like pairs of PQ-charged colored fermions is larger than one, which seems to encounter the domain wall problem. This apparent inconsistency is resolved by small instanton effects on the axion potential which operate as a PQ-violating bias term and allow the decay of domain walls. We propose a domain-wall-free UV completion for an IR model where the domain wall number appears larger than one. The model gives a prediction for a dark matter axion window, which is different from that of the ordinary post-inflationary QCD axion with domain wall number one.

Primary authors: NAKAI, Yuichiro; XU, Junxuan (TDLI); SUZUKI, Motoo; HOR, Shihwen

Presenter: XU, Junxuan (TDLI)

Session Classification: Parallel talks (2)

Contribution ID: **101** Type: **not specified**

Exploring the Landscape of Spontaneous CP Violation in Supersymmetric Theories

Wednesday, 27 August 2025 11:00 (20 minutes)

The strong CP problem remains one of the most significant unresolved issues in the Standard Model. A promising approach is to assume that CP is an exact symmetry of the Lagrangian, broken spontaneously by the vacuum. Supersymmetry (SUSY) provides a natural framework for such scenario, offering both protection of hierarchies and flat directions where spontaneous CP violation (SCPV) can occur. However, realizing physical CP-violating phases in concrete models is generally nontrivial and highly model-dependent. In this work, we study the stabilization of CP-violating phases in two distinct SUSY scenarios. First, we investigate SCPV by SUSY-conserving dynamics, extending the group-theoretic spurion formalism and introducing a method to determine whether the necessary condition for SCPV is satisfied only from the superpotential. Second, we construct a model in which CP is spontaneously broken along an approximate flat direction, stabilized by soft SUSY-breaking and non-perturbative effects. This setup predicts light pseudo-Goldstone bosons with masses determined by the SUSY-breaking scale. Our results provide a unified view of SCPV in SUSY theories and offer practical tools for realistic model building.

Primary authors: Mr LIU, Fangchao (TDLI, SJTU); NAKAGAWA, Shota (Tsung-Dao Lee Institute, Shanghai Jiao Tong University); NAKAI, Yuichiro; WANG, Yaoduo (TDLI)

Presenter: Mr LIU, Fangchao (TDLI, SJTU)

Session Classification: Parallel talks (3)

Contribution ID: **102** Type: **not specified**

Abelian-Higgs vortices in the oscillating axion background

Monday, 25 August 2025 14:30 (20 minutes)

Axion is one of the well-motivated candidates for dark matter and there have been many attempts for axion dark matter search. In this talk, we show novel aspects of the axion dark matter, which significantly modify the physics of vortex in the Abelian-Higgs model. Due to the axion-photon conversion, electromagnetic fields are induced in the magnetic core of the vortex. In numerical simulations, we find that the induced electromagnetic field is confined and resonantly enhanced in the vortex, which implies that the vortex acts as a cylindrical cavity. We also focus on the interaction of two vortices in the oscillating axion background, resulting in attractive or repulsive forces, even in the case with the BPS limit. These new features open up a new possibility for the axion dark matter search using superconducting devices.

Primary authors: Mr KITAJIMA, Naoya (Tohoku University); Mr NAKAGAWA, Shota (Tsung-Dao Lee Institute, Shanghai Jiao Tong University)

Presenter: Mr NAKAGAWA, Shota (Tsung-Dao Lee Institute, Shanghai Jiao Tong University)

Session Classification: Parallel talks (1)

Contribution ID: **103** Type: **not specified**

Chiral gravitational wave background from axion-like fields

Monday, 25 August 2025 14:50 (20 minutes)

Axions and axion-like particles can be probed through gravitational waves indirectly, often referred to as "audible axions". The usual concept of audible axion relies on the coupling between the axions and the gauge fields. Here we consider an axion-like mechanism with coupling to the Nieh–Yan term. This interaction leads to the direct and efficient production of gravitational waves during the radiation-dominated era, originating from the tachyonic instability of the gravitational perturbations with the Nieh–Yan term. We calculate the energy spectral density of the chiral gravitational wave background and the comoving energy density of axion-like fields. Based on the numerical results, we explore the parameter space of axion masses and decay constants for detectable gravitational wave signals, either in pulsar timing arrays or space-based gravitational wave detections. [2411.08691 & 2503.20778]

Primary author: ZHANG, Yun-Long (NAOC)

Presenter: ZHANG, Yun-Long (NAOC)

Session Classification: Parallel talks (1)

Contribution ID: **104** Type: **not specified**

Induced Domain Walls of QCD Axion, and Gravitational Waves

Monday, 25 August 2025 15:40 (20 minutes)

We show that heavy axion domain walls induce domain walls of the QCD axion through a mixing between the heavy axion and the QCD axion, even when the pre-inflationary initial condition is assumed for the QCD axion. The induced domain walls arise because the effective θ parameter changes across the heavy axion domain walls, shifting the potential minimum of the QCD axion. When the heavy axion domain walls collapse, the induced QCD axion domain walls collapse as well. This novel mechanism for producing the QCD axions can explain dark matter even with the axion decay constant as small as $calO(10^9)$ GeV. In particular, this scenario requires domain wall collapse near the QCD crossover, potentially accounting for the stochastic gravitational wave background suggested by recent pulsar timing array observations, including NANOGrav. Using this mechanism, it is also possible to easily create induced domain walls for string axions or axions with a large decay constant, which would otherwise be challenging. We also comment on the implications for cosmic birefringence using induced axion domain walls.

Primary author: MURAI, Kai (Tohoku U.)

Co-authors: TAKAHASHI, Fuminobu (Tohoku University); LEE, Junseok (Tohoku U.); YIN, Wen

Presenter: LEE, Junseok (Tohoku U.)

Session Classification: Parallel talks (1)

Contribution ID: **106** Type: **not specified**

Gauged B-L symmetry and leptogenesis from axion inflation

Tuesday, 26 August 2025 11:00 (30 minutes)

In the context of axion inflation, inflaton can couple to gauge fields through the Chern-Simons coupling. This coupling gives rise to an instability of helical U(1) gauge fields. If the B-L symmetry in the Standard Model is gauged, at the end of inflation through the chiral anomaly we have helical B-L magnetic fields and B-L asymmetry in the visible and sterile sector, while the total B-L asymmetry vanishes. It may be often the case that all the asymmetry finally cancels out in the thermal history of the Universe after inflation. But we succeeded in constructing a scenario where the present baryon asymmetry can be explained through the B-L genesis in this model. In this talk, I explain the essence for this scenario to be successful.

Primary author: KAMADA, Kohei (HIAS UCAS)

Presenter: KAMADA, Kohei (HIAS UCAS)

Session Classification: Plenary talks (2)

Contribution ID: **107** Type: **not specified**

Asymptotic GUT in extra dimension

Wednesday, 27 August 2025 09:00 (30 minutes)

Asymptotic unification, distinct from the conventional concept of unification, suggests that couplings unify at a non-trivial ultraviolet (UV) fixed point. Theory with an interacting UV fixed point is normally referred to as asymptotic safety to address the famous UV Landau pole problem. Alternative to a usual grand unified theory (GUT), an asymptotic GUT gradually unifies gauge couplings in the deep UV limit. Using an economical and realistic particle content setup, we demonstrate that asymptotic grand unification can be achieved in SO(10) with one extra dimension. One intermediate scale, the Pati-Salam symmetry breaking scale, is included below the compactification scale. The top, bottom and tau masses are split, and the smallness of the neutrino mass is explained via inverse seesaw. Due to the absence of large-dimensional Higgs representations, gauge couplings exhibit asymptotic safety and are thus asymptotically unified, regardless of their initial values. In contrast, Yukawa couplings can achieve asymptotic freedom if the negative gauge contributions dominate over the positive Yukawa terms.

Primary author: ZHOU, Ye-Ling (HIAS-UCAS)

Co-authors: FANG, Gao-Xiang (HIAS, UCAS, Hangzhou); WANG, Zhi-Wei (UESTC)

Presenter: ZHOU, Ye-Ling (HIAS-UCAS)

Session Classification: Plenary talks (3)

Contribution ID: **108** Type: **not specified**

Cold darkogenesis: Hints for baryon asymmetry and dark matter from the PTA signal

Wednesday, 27 August 2025 11:20 (20 minutes)

If the nano-Hz gravitational wave signal observed by Pulsar Timing Array (PTA) experiments originates from a strongly supercooled first-order phase transition, the resulting supercooling at $calO(1)$ GeV temperature necessitates a new mechanism for generating the baryon asymmetry and dark matter, as any pre-existing abundances are diluted. We propose a model of cold darkogenesis, where the winding number changing dynamics of a dark $SU(2)_{\rm D}$ Higgs field generate a dark asymmetry, subsequently transferred to the visible sector via neutron portal interactions. The scenario naturally explains the baryon asymmetry, asymmetric self-interacting dark matter, and the PTA signal, and will be tested in collider and direct detection experiments.

Primary authors: FUJIKURA, KOHEI (U. Tokyo); GIRMOHANTA, Sudhakantha (Tsung-Dao Lee Institute, Shanghai Jiao Tong University); NAKAI, Yuichiro; ZHANG, Zhihao (TDLI)

Presenter: GIRMOHANTA, Sudhakantha (Tsung-Dao Lee Institute, Shanghai Jiao Tong University)

Session Classification: Parallel talks (3)

Contribution ID: **109** Type: **not specified**

Post-Sphaleron Darkogenesis

Wednesday, 27 August 2025 11:40 (20 minutes)

A supercooled phase transition in a nearly conformal dark sector can provide a natural setting for darkogenesis via its out-of-equilibrium dynamics, where a particle-antiparticle number asymmetry in the dark sector can be reprocessed into the visible sector, yielding the observed baryon asymmetry and an asymmetric dark matter. We consider a scenario where the number asymmetry is generated from the decay of a mother particle produced via parametric resonance during the phase transition induced due to its coupling to the dilaton associated with spontaneous breaking of scale invariance. It is shown that the correct baryon asymmetry and dark matter abundance can be realized for a dark phase transition at $\mathcal{O}(1)$ GeV, which can also explain the nano-Hz gravitational wave signal reported by pulsar timing array experiments. The scenario will be tested further in neutron-antineutron oscillation experiments.

Primary authors: GIRMOHANTA, Sudhakantha; NAKAI, Yuichiro; ZHANG, Zhihao (TDLI)

Presenter: ZHANG, Zhihao (TDLI)

Session Classification: Parallel talks (3)

Contribution ID: **110** Type: **not specified**

Bias with a Timer: Axion Domain Wall Decay and Dark Matter

Monday, 25 August 2025 16:00 (20 minutes)

We explore the interplay of the post-inflationary QCD axion and a light scalar field for the axion domain wall decay and dark matter (DM).
The interaction between the scalar field and the axion effectively serves as an explicit Peccei-Quinn (PQ) violating term. At a temperature below the PQ phase transition, the effective PQ violating interaction generates the axion potential which generally contains multiple degenerate vacua leading to the formation of the axion string-domain wall networks. Then we explore the evolution of string-wall system as the QCD phase transition provides another contribution to the axion potential making domain walls decay.We keep track of the evolution of the axion-scalar system and discuss the production of the axion DM through the domain wall decay and the misalignment contribution.We also discuss the viable parameter spaces in our model.
We find some interesting domain wall strcutures that the string-wall network in some cases can decay due to its structural instability, rather than the volume pressure, and the correct axion DM abundance is realized with the decay constant larger than that of the conventional post-inflationary QCD axion without fine tuning.

Primary authors: SUZUKI, Motoo; NAKAGAWA, Shota (Tsung-Dao Lee Institute, Shanghai Jiao Tong University); NAKAI, Yuichiro; HAO, Yuxuan (TDLI)

Presenter: HAO, Yuxuan (TDLI)

Session Classification: Parallel talks (1)

Contribution ID: **111** Type: **not specified**

Boosted dark matter in white dwarfs

Monday, 25 August 2025 16:20 (20 minutes)

White dwarfs offer a compelling avenue for probing interactions of dark matter particles, particularly in the challenging sub-GeV mass regime. The constraints derived from these celestial objects strongly depend on the existence of high dark matter densities in the corresponding regions of the Universe, where white dwarfs are observed. This implies that excluding the parameter space using local white dwarfs would present a significant challenge, primarily due to the low dark matter density in the solar neighbourhood. This limitation prompts the exploration of alternative scenarios involving dark matter particles with a diverse spectrum of kinetic energies. In this work, we investigate how these dark matter particles traverse the star, interact with stellar matter, and ultimately get captured. To accomplish this, we approximate the dark matter flux as a delta function and we assume that fermionic dark matter interacts with stellar matter either through a vector or a scalar interaction. In our computations, we consider how interactions might vary across different energy regimes, from high-energy deep inelastic scattering and inelastic scatterings via the production of N− and Δ− resonances to lower-energy elastic interactions with nucleons and nuclei. Our study models these inelastic resonant interactions with dark matter and vector or scalar mediators for the very first time. We provide insights into the specific conditions required for successfully boosted dark matter capture in white dwarfs. We found that, in general, dark matter capture is most likely to occur at low energies, as expected. However, in the high-energy regime, there remains a small window for capture through resonant and deep inelastic scattering processes.

Primary authors: RAMIREZ-QUEZADA, Maura; HOR, Shihwen (TDLI); HOEFKEN ZINK, Jaime

Presenter: HOR, Shihwen (TDLI)

Session Classification: Parallel talks (1)

Contribution ID: **112** Type: **not specified**

Non-holomorphic modular $\mathcal{A}_4$ symmetric scotogenic model

Wednesday, 27 August 2025 12:00 (20 minutes)

The present talk will cover an extension of a scotogenic and its modular $\mathcal{A}_4$ variation a step forward and demonstrates scotogenic modular $\mathcal{A}_4$ non-supersymmetric realization. To achieve this non-holomorphic modular symmetries come to rescue. Advantage of the current construction is the compactness of the model content and absence of the supersymmetric fields. Neutrino mass is generated through a canonical scotogenic mechanism. The allowed values of the VEV of the τ modulus are $\tau \simeq w$ and $\mathrm{Im}[\tau] \approx 2$. The non-holomorphic modular $\mathcal{A}_4$ symmetry leads to correlations among the neutrino observables.

Primary authors: Prof. NOMURA, Takaaki (Sichuan University); Prof. OKADA, Hiroshi (Henan Normal University); POPOV, Oleg (Shenzhen MSU-BIT University)

Presenter: POPOV, Oleg (Shenzhen MSU-BIT University)

Session Classification: Parallel talks (3)

Contribution ID: **113** Type: **not specified**

Composite Asymmetric Dark Matter from Primordial Black Holes

Monday, 25 August 2025 16:40 (20 minutes)

We investigate a cogenesis scenario for composite asymmetric dark matter framework: a dark sector has a similar strong dynamics to quantum chromodynamics in the standard model, and the dark-sector counterpart of baryons is the dark matter candidate. The Hawking evaporation of primordial black holes plays a role of a source of heavy scalar particles whose CP-violating decay into quarks and dark quarks provides particle–anti-particle asymmetries of baryon and dark matter, respectively. Primordial black holes should evaporate after electroweak phase transition and before the big-bang nucleosynthesis for explaining the baryon asymmetry of the Universe and for consistent cosmology. We find that this scenario explains the observed values for both baryon and dark matter energy densities as the heavy scalar particles with a mass of 10^6-10^9 GeV and the primordial black holes with a mass of 10^7-10^9 g.

Primary author: UCHIDA, Yoshiki (South China Normal University)

Presenter: UCHIDA, Yoshiki (South China Normal University)

Session Classification: Parallel talks (1)

Contribution ID: **114** Type: **not specified**

Axion Magnetic Resonance in Low-Energy Precision Experiments

Monday, 25 August 2025 11:00 (30 minutes)

It is well-known that axions and photons can coherently convert into each other in a background magnetic field, a phenomenon commonly observed in a mixed two-level quantum system such as neutrino oscillations and nuclear spin processions. Similar to the nuclear magnetic resonance and spin flips in a qubit system, we point out that an periodic (in time or space) background magnetic field can significantly enhance the axion-photon conversion. We denote this resonance as the Axion-Magnetic Resonance (AMR).

In this talk, I will illustrate the theoretical and experimental implications of the AMR, in particular in the context of laser-based axion searches and solar axion experiments (helioscopes). I will show its relevance for interesting some ALPs models and its capability in distinguishing different QCD axion models (KSVZ and DSFZ), independent of the axion relic abundance or cosmological history.

Presenter: SUN, Chen

Session Classification: Plenary talks (1)

Contribution ID: **115** Type: **not specified**

Machine Learning in the Precision Era

Monday, 25 August 2025 10:30 (30 minutes)

Presenter: LI, Lingfeng

Session Classification: Plenary talks (1)

Contribution ID: **116** Type: **not specified**

Hunting for axions in rector neutrino experiment

Monday, 25 August 2025 09:30 (30 minutes)

Presenter: WU, Lei

Session Classification: Plenary talks (1)

Contribution ID: **117** Type: **not specified**

Inflation beyond slow-roll, non-Gaussianity, and PBHs

Tuesday, 26 August 2025 09:30 (30 minutes)

Presenter: PI, Shi

Session Classification: Plenary talks (2)

Contribution ID: **118** Type: **not specified**

Lattice simulation for symmetry breaking

Presenter: BIAN, Ligong

Session Classification: Plenary talks (2)

Contribution ID: **119** Type: **not specified**

New Gravitational Wave Sources and Dark Matter Mechanisms from Cosmic Phase Transitions

Tuesday, 26 August 2025 10:30 (30 minutes)

Presenter: HUANG, Fapeng

Session Classification: Plenary talks (2)

Contribution ID: **120** Type: **not specified**

Light particle emissions from cosmic strings

Monday, 25 August 2025 11:30 (30 minutes)

Cosmic string is a topological defect associated with the spontaneous symmetry breaking in the early universe. After the formation of cosmic strings, they form a network and evolve following the scaling regime. In this talk, I present light particle emissions from the cosmic string network. In particular, I focus on the procudtion of the axion and other pseudo-Nambu-Goldstone bosons and show that they can account for the dark matter and dark radiation in our universe today. I will show that such cosmic strings can be testable by combining the gravitational wave observations and the CMB observations.

Presenter: KITAJIMA, Naoya

Session Classification: Plenary talks (1)

Contribution ID: **121** Type: **not specified**

Light particle emissions from cosmic strings

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Primary author: KITAJIMA, Naoya (Tohoku University)

Presenter: KITAJIMA, Naoya (Tohoku University)

Contribution ID: **125** Type: **not specified**

Axion Magnetic Resonance in Low-Energy Precision Experiments

It is well-known that axions and photons can coherently convert into each other in a background magnetic field, a phenomenon commonly observed in a mixed two-level quantum system such as neutrino oscillations and nuclear spin processions. Similar to the nuclear magnetic resonance and spin flips in a qubit system, we point out that an periodic (in time or space) background magnetic field can significantly enhance the axion-photon conversion. We denote this resonance as the Axion-Magnetic Resonance (AMR).

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Primary author: SUN, Chen (ICTP, Trieste)

Presenter: SUN, Chen (ICTP, Trieste)