KEK Theory Meeting on Particle Physics Phenomenology (KEK-PH2025winter)

Report of Contributions

https://conference-indico.kek.jp/e/278

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

opening

Tuesday, February 18, 2025 10:00 AM (10 minutes)

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

closing

Friday, February 21, 2025 12:20 PM (40 minutes)

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

CERN Future Circular Collider: an electroweak and flavour factory

Tuesday, February 18, 2025 10:10 AM (40 minutes)

Presenter: GROJEAN, Christophe

Session Classification: plenary

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

Quantum Entanglement and Emerging Symmetry

Tuesday, February 18, 2025 11:10 AM (40 minutes)

Presenter: LOW, Ian

Session Classification: plenary

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

Recent results from ATLAS and prospects for HL-LHC

Tuesday, February 18, 2025 1:30 PM (40 minutes)

Presenter: HIROSE, Shigeki

Session Classification: plenary

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

Recent results in MLPhys — ”Machine Learning Physics” initiative in Japan

Tuesday, February 18, 2025 2:10 PM (40 minutes)

Presenter: HASHIMOTO, Koji

Session Classification: plenary

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

Majorana phases beyond neutrinoless double beta decay

Wednesday, February 19, 2025 9:00 AM (40 minutes)

Presenter: LIGETI, Zoltan

Session Classification: plenary

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

Recent updates and future prospects of the Belle II experiment

Wednesday, February 19, 2025 9:40 AM (40 minutes)

I will report recent results and prospects for future results from the Belle II experiment

Presenter: SOFFER, Abner

Session Classification: plenary

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

Flavor Patterns of Fundamental Particles from Quantum Entanglement?

Wednesday, February 19, 2025 10:30 AM (40 minutes)

The Cabibbo-Kobayashi-Maskawa (CKM) matrix, which controls flavor mixing between the three generations of quark fermions, is a key input to the Standard Model of particle physics. In this paper, we identify a surprising connection between quantum entanglement and the degree of quark mixing. Focusing on a specific limit of 2⟶2 quark scattering mediated by electroweak bosons, we find that the quantum entanglement generated by scattering is minimized when the CKM matrix is almost (but not exactly) diagonal, in qualitative agreement with observation. With the discovery of neutrino masses and mixings, additional angles are needed to parametrize the Pontecorvo-Maki-Nakagawa-Sakata (PMNS) matrix in the lepton sector. Applying the same logic, we find that quantum entanglement is minimized when the PMNS matrix features two large angles and a smaller one, again in qualitative agreement with observation, plus a hint for suppressed CP violation. We speculate on the (unlikely but tantalizing) possibility that minimization of quantum entanglement might be a fundamental principle that determines particle physics input parameters.

Presenter: TRIFINOPOULOS, Sokratis

Session Classification: plenary

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

Direct Dark Matter Detection with Liquid Xenon Detectors

Wednesday, February 19, 2025 11:10 AM (40 minutes)

Presenter: KAZAMA, Shingo

Session Classification: plenary

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

Dark Matter Detection using Quantum Bits

Thursday, February 20, 2025 9:00 AM (40 minutes)

I will discuss a possibility to use quantum bits (qubits) for wave-like-dark-matter detection. I will explain the basic idea and show the expected sensitivity. I will also discuss an idea to enhance the sensitivity using quantum nature of the qubits.

Presenter: MOROI, Takeo

Session Classification: plenary

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

Soft Collinear Effective Theory for heavy dark matter annihilation

Thursday, February 20, 2025 9:40 AM (40 minutes)

Electroweakly interacting stable particles in the (1 – 10) TeV mass range can be a dark matter candidate with rich testability.
In particular, gamma-ray line-like features are expected to be a smoking-gun signature for indirect detection.
In this framework, one fundamental question follows; how to distinguish DM spin among DM candidates with the same electroweak interaction by contrasting their predictions?
A straightforward but crucial effort is to derive annihilation spectra with higher accuracy.
However, one encounters complexities due to non-perturbative corrections following the mass hierarchy between heavy DM and electroweak mediators.
In this talk, we present how to construct Soft-Collinear Effective field Theory (SCET) to systematically resum large Sudakov logarithmic corrections for spin-0, 1/2 and 1 DM, and to achieve accurate prediction. We give a special focus on spin-1 DM, which is the last piece to complete all the possible predictions.
After specifying the leading operators to describe heavy DM annihilation in SCET, we discuss how to extract spin-dependence from the predicted gamma-ray spectrum.

Presenter: FUJIWARA, Motoko

Session Classification: plenary

Contribution ID: **14** Type: **not specified**

Undulators as axion factories

Thursday, February 20, 2025 10:30 AM (40 minutes)

I will present a low-cost experimental proposal for axion searches at synchrotron radiation facilities, such as SPring-8, NanoTerasu, and Photon Factory. Specifically, I will discuss the method for calculating axion production in an undulator, a type of light source widely used across various fields. By positioning an axion detector outside the shield used in the primary experiments, we can conduct a sustainable, coexisting axion search experiment. This approach has the potential to set a world record in the light-shining-through-a-wall experiment for probing the heavy axion mass range.

Presenter: YIN, Wen

Session Classification: plenary

Contribution ID: **15** Type: **not specified**

Cosmic Microwave Background

Thursday, February 20, 2025 11:10 AM (40 minutes)

Presenter: KUSAKA, Akito

Session Classification: plenary

Contribution ID: **16** Type: **not specified**

Candidate de Sitter Vacua

Friday, February 21, 2025 9:00 AM (40 minutes)

Presenter: MORITZ, Jacob

Session Classification: plenary

Contribution ID: **17** Type: **not specified**

Cascade of Energetic SM Particles

Friday, February 21, 2025 11:00 AM (40 minutes)

Presenter: MUKAIDA, Kyohei

Session Classification: plenary

Contribution ID: **18** Type: **not specified**

The bubble wall velocity in cosmological phase transitions

Friday, February 21, 2025 11:40 AM (40 minutes)

Cosmological first order phase transitions are a promising source of gravitational waves, and a possible explanation of the baryon asymmetry and dark matter abundance.
Predicting the phenomenological consequences of such phase transitions requires knowledge of the expansion velocity of the bubbles formed in a phase transition.
In this talk, I will present WallGo, a software package for the computation of bubble wall velocities. WallGo is the first publicly available code that computes the matrix elements, collision integrals Boltzmann equation and scalar field equation of motion for user-defined models. I will present results obtained with WallGo, and discuss its limitations.
Lastly, I will discuss several simplifying regimes in the computation of the wall velocity, such as the ballistic limit and a large jump in degrees of freedom.

Presenter: VAN DE VIS, Jorinde

Session Classification: plenary

Contribution ID: **19** Type: **not specified**

Flavor anomalies and 2HDM with flavor symmetry

Tuesday, February 18, 2025 3:20 PM (20 minutes)

Anomalies in b -> s l l and b -> c l nu decays have persisted for over a decade. In this talk, I will explore the current landscape from three perspectives. First, global fits offer a model-independent approach to understanding the latest data. I will present our recent work on global fits incorporating around 200 binned observables, which reveals intriguing indications that new physics may manifest in the Wilson coefficient C9. Second, the Standard Model Effective Field Theory (SMEFT) provides a less model-dependent interpretation of experimental data and fitting outcomes. I will highlight several compelling predictions that emerge when data is analyzed through the SMEFT framework. Finally, the exploration and testing of specific new physics models remain crucial. I will introduce and examine a specific Two-Higgs-Doublet Model (2HDM) with gauge symmetry imposed on fermions, which accommodates anomalies in both neutral and charged currents.

Presenter: XU, Fanrong

Session Classification: parallel session A

Contribution ID: **20** Type: **not specified**

The possible solution to V_cb puzzle from nontrivial analyticity of quark propagator

Tuesday, February 18, 2025 3:40 PM (20 minutes)

There is a longstanding tension between inclusive and exclusive |Vcb| determinations of Cabibbo-Kobayashi-Maskawa matrix element, i.e. Vcb puzzle. In this work, a nontrivial analytical structure of the quark propagator, indicated from the perspective of color confinement, is included for the first time in the inclusive B decay. To discuss the possibility of solving the Vcb puzzle, the observables B_d^0 lifetime and |Vcb| are analyzed. It is shown that the previous inclusive value based on operator product expansion is improved and thereby a possible resolution to the Vcb puzzle is given, which can be clarified with future determinations of parameters describing the complex conjugate poles.

Presenter: ZHU, Jinglong

Session Classification: parallel session A

Contribution ID: **21** Type: **not specified**

A novel approach to charm mixing

Tuesday, February 18, 2025 4:00 PM (20 minutes)

For $D^0 - \bar{D}^0$ mixing, it is known that the operator product expansion cannot properly reproduce the order of magnitude of the experimental data. The difficulty in the conventional method arises from the significant cancellation due to the GIM mechanism. In this work, we analyze mass difference based on the Schwinger-Dyson approach. It is shown that the order of magnitude of the observable can be improved, compared to the conventional result.

Presenter: UMEEDA, Hiroyuki

Session Classification: parallel session A

Contribution ID: **22** Type: **not specified**

Analysis of Flavor Models by Diffusion Model

Tuesday, February 18, 2025 4:50 PM (20 minutes)

In conventional analyses of flavor models, the search space of parameters is often restricted to a certain range to optimize the parameters of the theory within a realistic computational time. In this talk, we propose an analytical method utilizing a diffusion model, which is a type of generative artificial intelligence. This strategy can be applied independently of the specific details of the models in contrast to the conventional methods. Through concrete examples, we will discuss how the predictions of flavor models can be evaluated from a bird's-eye view based on the inverse problem approach, where the machine generates various candidates of parameters that reproduce experimental values.

Presenter: NISHIMURA, Satsuki

Session Classification: parallel session A

Contribution ID: **23** Type: **not specified**

Heavy quark symmetry behind b → c semileptonic sum rule

Tuesday, February 18, 2025 5:10 PM (20 minutes)

Lepton flavor universality violations in semileptonic b⟶c transitions have garnered attention over a decade. For RH_c=BR(H_b⟶H_cτν)/BR(H_b⟶H_cℓν) with ℓ being e,μ, a sum rule among RD, RD∗ and RΛc was proposed to check consistency in the experimental results independently of new physics models. We revisit this relation from the perspective of the heavy quark symmetry. We derive a sum rule holding exactly in the heavy quark limit and clarify how model-dependent corrections are introduced in a realistic situation.

Presenter: IGURO, Syuhei

Session Classification: parallel session A

Contribution ID: **24** Type: **not specified**

Are Fractals Behind Flavor Mixing of the SM?

Wednesday, February 19, 2025 5:10 PM (20 minutes)

We explore the idea that the underlying flavour structure of the Standard Model could be determined by a fractal geometry. We consider theory space on a Sierpenski-like geometry. Fermion mass chains on Sierpinski-like geometry with three decorations(iterations) lead to three zero modes, which can be identified with three generations of the Standard Model. A single parameter expansion for each of the fermion mass matrices is achieved which explains the hierarchial masses as well as the mixing angles for the lepton sector. Extensions to the quark sector and related phenomenology are briefly discussed.

Presenter: SINGH, Aadarsh

Session Classification: parallel session A

Contribution ID: **25** Type: **not specified**

Evanescent contribution of the QCD theta angle

Tuesday, February 18, 2025 3:20 PM (20 minutes)

In this talk, we evaluate the QCD theta angle radiatively induced at the two-loop level using the dimensional regularization with the BMHV scheme in a simplified model. When the Lagrangian is promoted into d-dimensional space through the dimensional regularization, evanescent operators are introduced, which break the chiral symmetry. Consequently, a parity-odd fermion loop with the BMHV scheme generates an evanescent contribution that deviates from the original chiral symmetry. We carefully classify the evanescent contribution into two types: one originating from the evanescent operator and the other directly produced by the two-loop calculation. These unphysical contributions can be removed from the renormalization equation for the QCD theta angle by re-parameterizing the angle.

Presenter: OSAMURA, Naohiro

Session Classification: parallel session B

Contribution ID: **26** Type: **not specified**

Spontaneous CP violation in supersymmetric QCD

Tuesday, February 18, 2025 3:40 PM (20 minutes)

We investigate a composite model of spontaneous CP violation based on a new supersymmetric QCD as a solution to the strong CP problem. The scalar components of the meson chiral superfields obtain complex vacuum expectation values to break CP symmetry spontaneously. Then, wavefunction renormalization for the quark kinetic terms provides the Cabibbo-Kobayashi-Maskawa (CKM) phase, while the strong CP phase θ is protected by nonrenormalization of the superpotential and hermiticity of the wavefunction renormalization factor. In our model, the right-handed down-type quark multiplets are given by composite states, enhancing their couplings to CP breaking fields, which is essential to realize the observed CKM phase. The non-perturbative dynamics generates the scale of spontaneous CP violation hierarchically lower than the Planck scale. We discuss potential corrections to θ and find a viable parameter space of the model to solve the strong CP problem without fine-tuning.

Presenter: WANG, Yaoduo

Session Classification: parallel session B

Contribution ID: **27** Type: **not specified**

Does finetuning make D-term contributions smaller in natural grand unified theories with spontaneous supersymmetry breaking?

Tuesday, February 18, 2025 4:00 PM (20 minutes)

We explore the natural grand unified theory (GUT) with spontaneous supersymmetry (SUSY) breaking, focusing on the contribution to sfermion and Higgs masses. Natural GUTs, which introduce all terms allowed by SO(10) × U (1)A symmetry with O(1) coefficients, provide a solution to the problems in SUSY GUTs. Although it is also possible to introduce spontaneous SUSY breaking, it predicts D-term contribution to sfermion and Higgs masses dominates the F-term contribution, that potentially leads to the SUSY flavor problem. Fortunately, it also predicts high-scale SUSY, which avoids the SUSY flavor problem but leads to the need for fine-tuning to obtain the electroweak scale and predicts superheavy Higgsino mass unless the D-term contribution becomes comparable with the F-term contribution. We discuss whether it is possible to suppress the D-term contribution while maintaining the F-term contribution through the tuning of O(1) coefficients in the natural GUT with spontaneous SUSY breaking. Our results indicate that it is impossible. This also suggests that the Higgsino is not a candidate for dark matter in the scenario.

Presenter: TANII, Taiju

Session Classification: parallel session B

Contribution ID: **28** Type: **not specified**

Gauge symmetry breaking with two dimensional sphere as extra dimensions

Tuesday, February 18, 2025 5:10 PM (20 minutes)

In the grand unified theory, the Higgs mechanism is commonly used. However, as an alternative approach, extra dimensions with non-zero curvature can lead to gauge symmetry breaking.

We have constructed a Yang-Mills theory with extra dimensions as two-dimensional sphere(S^2). As a result, the curvature of the extra dimensions and the non-commutative nature of the gauge group lead to a different gauge symmetry breaking process and origin of Higgs from conventional models such as those with S^1 and T^2.

In this talk, we report on the gauge symmetry breaking observed in the Kaluza-Klein expansion of four-dimensional gauge fields.

Presenter: ISHIKAWA, Hiroki

Session Classification: parallel session B

Contribution ID: **29** Type: **not specified**

Wiggly dilaton: a landscape of spontaneously broken scale invariance

Tuesday, February 18, 2025 4:50 PM (20 minutes)

The dilaton emerges as a pseudo-Nambu-Goldstone boson (pNGB) associated with the spontaneous breaking of scale invariance in a nearly conformal field theory (CFT). We show the existence of a wiggly dilaton potential that contains multiple vacuum solutions in a five-dimensional (5D) holographic formulation. The wiggly feature originates from boundary potentials of a 5D axion-like scalar field, whose naturally small bulk mass parameter corresponds to a marginally-relevant deformation of the dual CFT. Depending on the energy density of a boundary 3-brane, our model can be used to generate a light dilaton or provide a relaxion potential.

Presenter: QIU, Yu-Cheng

Session Classification: parallel session B

Contribution ID: **30** Type: **not specified**

Mass spectrum of the extra-dimensional components of gauge fields in Yang-Mills theory with extra dimensions of two-dimensional sphere

Tuesday, February 18, 2025 5:30 PM (20 minutes)

The theoretical origin of the Higgs boson remains unclear. Yang-Mills theories in higher dimensions are good candidates to address this issue.
We have constructed a Yang-Mills theory with extra dimensions of two-dimensional sphere. In this model, compared to conventional models such as those with S^1 and T^2, curvature of the extra dimensions and the non-commutative nature of the gauge group result in different features in gauge symmetry breaking process and the origin of scalar fields.
In this talk, we will report the mass spectrum obtained from the Kaluza-Klein expansion of the gauge field components in the extra dimensions, which appear as scalar fields in our four-dimensional spacetime.

Presenter: HONDA, Yuki

Session Classification: parallel session B

Contribution ID: **31** Type: **not specified**

Single top plus Higgs production at the LHC

Wednesday, February 19, 2025 1:30 PM (20 minutes)

We study the single top plus Higgs production process at the LHC with a CP violating Yukawa coupling from a dimension-6 operator. The amplitude of the subprocess ub>dtH is obtained both in the Unitary (U) and Feynman-Diagram (FD) gauges. Energy and angular distributions of the cross section and CP violating asymmetries are understood from the interference among the FD gauge amplitudes.

Presenter: ZHENG, Yajuan

Session Classification: parallel session A

Contribution ID: **32** Type: **not specified**

Transformers for jet tagging

Wednesday, February 19, 2025 1:50 PM (20 minutes)

Attention-based transformer models have become increasingly prevalent in collider analysis, offering enhanced performance for tasks such as jet tagging. However, they are computationally intensive and require substantial data for training. we introduce a new jet classification network using an MLP mixer, where two subsequent MLP operations serve to transform particle and feature tokens over the jet constituents. The transformed particles are combined with subjet information using multi-head cross-attention so that the network is invariant under the permutation of the jet constituents. The network structure is closely related to the multiscale nature of HEP events.
The proposed network demonstrates comparable classification performance to state-of-the-art models while boosting computational efficiency drastically. The network structure can be applied to the various collider processes.

Presenter: HAMMAD, Ahmed

Session Classification: parallel session A

Contribution ID: **33** Type: **not specified**

Dark photon pair production via off-shell dark Higgs at FASER

Wednesday, February 19, 2025 2:10 PM (20 minutes)

We consider a dark photon model in which the dark U(1) gauge symmetry is spontaneously broken by a vacuum expectation value of a new scalar boson. We focus on the ForwArd Search ExpeRiment (FASER) and calculate its sensitivity to the dark photon produced from the off-shell decay of the new scalar boson. It is found that the off-shell production extends the sensitivity region beyond the kinematical threshold of the on-shell decay of the scalar boson, and that the sensitivity region can be spanned to unexplored region. We also show the parameter space in which perturbative calculation is valid for the unitarity of an S matrix.

Presenter: NAKASHIMA, Yohei

Session Classification: parallel session A

Contribution ID: **34** Type: **not specified**

T violation at a future neutrino factory

Wednesday, February 19, 2025 3:00 PM (20 minutes)

We study the possibility of measuring T (time reversal) violation in a future long baseline neutrino oscillation experiment. By assuming a neutrino factory as a staging scenario of a muon collider at the J-PARC site, we find that the ν_e ⟶ ν_μ oscillation probabilities can be measured with a good accuracy at the Hyper-Kamiokande detector. By comparing with the probability of the time-reversal process, ν_μ ⟶ ν_e, measured at the T2K/T2HK experiments, one can determine the CP phase δ in the neutrino mixing matrix if | sin(δ)| is large enough. The determination of δ can be made with poor knowledge of the matter density of the earth as T violation is almost insensitive to the matter effects. The comparison of CP and T-violation measurements, ‘a la the CPT theorem, provides us with a non-trivial check of the three neutrino paradigm based on the quantum field theory.

Presenter: SUGAMA, Sho

Session Classification: parallel session A

Contribution ID: **35** Type: **not specified**

Higgs Boson Production at μ^+ μ^+ Colliders

Wednesday, February 19, 2025 3:20 PM (20 minutes)

Motivated by recent advancements in antimuon cooling, we study Higgs boson production at μ^+ μ^+ colliders at high energy. Since both initial-state particles are positively charged, there is no W boson fusion at the leading order, as it requires a W^+ W^− pair. However, we find that the cross section of the higher-order, γ- and Z-mediated W boson fusion process is large at high center-of-mass energies √s, growing as (log s)^3. This is in contrast to the (log s) behavior of the leading-order W boson fusion. Thus, even though it is a higher-order process, the rate of Higgs boson production for 10 TeV energies at μ^+ μ^+ colliders with polarized beams can be as high as about half of the one at μ^+ μ^− colliders, assuming the same integrated luminosity. To calculate the cross section of this process accurately, we carefully treat the collinear emission of the photon in the intermediate state. The thereby obtained large cross section furthermore shows the significance of Higgs production with an extra W boson in the final state also at μ^+ μ^− and e^+ e^− colliders.

Presenter: TREUER, Lukas

Session Classification: parallel session A

Contribution ID: **36** Type: **not specified**

Verifying the Resonance Schemes of Unstable Particles at Lepton Colliders

Wednesday, February 19, 2025 3:40 PM (20 minutes)

We propose practical ways of differentiating the various (Breit-Wigner, theoretical, and energy-dependent) resonance schemes of unstable particles at lepton colliders. First, the energy-dependent scheme can be distinguished from the other two by fitting the Z lineshape scan and forward-backward asymmetries at LEP and future lepton colliders with the Z mass mZ, decay width ΓZ, and coupling strength as fitting parameters. Although the Breit-Wigner and theoretical schemes work equally well, the scheme conversion requires the decay width ΓZ to scale inversely with mZ rather than the usual linear dependence from theoretical calculation. These contradicting behaviors can be used to distinguish the Breit-Wigner and theoretical schemes by the precision Z measurements with single parameter (mZ) fit at future lepton colliders. For the WW threshold scan, its combination with the precise Fermi constant provides another way of distinguishing the Breit-Wigner and theoretical schemes.

Presenter: MIN, Ui

Session Classification: parallel session A

Contribution ID: **37** Type: **not specified**

Prospects for quantum process tomography at high energies

Wednesday, February 19, 2025 4:30 PM (20 minutes)

In quantum information theory, the evolution of an open quantum system – a unitary evolution with the environment followed by a measurement – is described by a Quantum Channel or, more generally, a Quantum Instrument. In this talk, I will formulate spin and flavour measurements in collider experiments as a Quantum Instrument. We demonstrate that the Choi matrix, which completely determines input-output transitions, can be both theoretically computed from a given theoretical model (e.g. the Standard Model) and experimentally reconstructed from a set of final state measurements (quantum state tomography) using varied input states. The reconstruction of the Choi matrix, known as quantum process tomography, offers a powerful new approach for probing potential extensions of the Standard Model within the QFT framework and also provides a fundamental test of Quantum Mechanics itself. As an example, I will outline a quantum process tomography approach applied to the e+ e- -> t tbar process at a polarized lepton collider.

Presenter: SAKURAI, Kazuki

Session Classification: parallel session A

Contribution ID: **38** Type: **not specified**

New Physics Implications of Vector Boson Fusion Searches

Wednesday, February 19, 2025 4:50 PM (20 minutes)

LHC searches for nonstandard scalars in vector boson fusion (VBF) production processes can be particularly efficient in probing scalars belonging to triplet or higher multiplet representations of the Standard Model SU(2)L gauge group. They can be especially relevant for models where the additional scalars do not have any tree-level couplings to the Standard Model fermions, rendering VBF as their primary production mode at the LHC. In this work we employ the latest LHC data from VBF resonance searches to constrain the properties of nonstandard scalars, taking the Georgi-Machacek model as a prototypical example. We explicitly demonstrate how a combination of theoretical and phenomenological constraints can push the GM model toward the decoupling limit. Our analysis suggests that the VBF searches can provide key insights into the composition of the electroweak vacuum expectation value.

Presenter: GHOSH, Nivedita

Session Classification: parallel session A

Contribution ID: **39** Type: **not specified**

Photon Proliferation Effect from N-body ultralight DM annihilation

Wednesday, February 19, 2025 1:30 PM (20 minutes)

I will demonstrate a general photon proliferation effect from N-body ultralight dark matter (DM) annihilation in the early Universe, which can induce a drastic photon-temperature shift after neutrino decoupling. For pseudoscalar DM mass below the eV scale, I will show that the photon proliferation effect becomes significant as the mass approaches the ultralight end, presenting the leading constraints on the DM-photon coupling, DM self-interaction, and DM-electron coupling.

Presenter: LI, Shaoping

Session Classification: parallel session B

Contribution ID: **40** Type: **not specified**

Composite Dark Matter with Forbidden Annihilation

Wednesday, February 19, 2025 1:50 PM (20 minutes)

A dark matter model with QCD-like SU(N) gauge symmetry and electroweakly interacting dark quarks is discussed. In this model, the lightest G-parity odd dark pion is a main component of dark matter. I will discuss the relation between the mass spectrum of dark pions and annihilation channels which mainly contribute to the relic abundance. When the masses of dark matter and heavier dark pions are degenerate, dark matter mainly annihilates into the heavier dark pions and realizes heavy dark matter whose mass is O(1-10) TeV. I will also discuss the Sommerfeld effect of the annihilation channels.

Presenter: YAMANAKA, Takumu

Session Classification: parallel session B

Contribution ID: **41** Type: **not specified**

pseudo-Nambu-Goldstone-boson as a Dark Matter Candidate: A Model with Three Complex Scalars under Z3 Symmetry

Wednesday, February 19, 2025 2:10 PM (20 minutes)

This study explores a dark matter model where the pseudo-Nambu-Goldstone boson (pNGB) emerges as a viable candidate, resulting from the spontaneous breaking of a U(1) symmetry and stabilized by a Z3 discrete symmetry which naturally emerges as a residual symmetry. The model introduces three complex scalar fields invariant under Standard Model (SM) gauge symmetries, naturally suppressing direct detection signals. We plan to investigate the thermal relic abundance, gauge kinetic mixing, and annihilation channels. Furthermore, we plan to examine boosted dark matter (semi-annihilation) channels, a feature of Z3-symmetric models.

Presenter: SHEIKH, Riasat

Session Classification: parallel session B

Contribution ID: **42** Type: **not specified**

Excited bound states and their role in dark matter production

Wednesday, February 19, 2025 3:00 PM (20 minutes)

I explore the impact of highly excited bound states on the evolution of number densities of new physics particles, specifically dark matter, in the early Universe.

Higher excited states play a crucial role in non-Abelian interactions, going as far as preventing a complete decoupling in the early Universe and thus preventing the constituent particle from freezing out. Instead, a continuous depletion is driven by consecutive bound state formation and decay in the regime consistent with perturbativity and unitarity.

I will highlight how the mechanism has profound impact in a simplified dark matter model featuring a colored and electrically charged t-channel mediator. The focus is hereby on the regime of superWIMP production which is commonly characterized by a mediator freeze-out followed by its late decay into dark matter. In contrast, we find that excited states render mediator depletion efficient all the way until its decay, introducing a dependence of the dark matter density on the mediator lifetime as a novel feature. The impact of bound states on the viable dark matter mass can amount to an order of magnitude, relaxing constraints from Lyman-α observations.

Presenter: LEDERER, Stefan

Session Classification: parallel session B

Contribution ID: **43** Type: **not specified**

Black String in the Standard Model

Wednesday, February 19, 2025 3:20 PM (20 minutes)

We found black string solutions in the 4 dimensional standard model, whose existence is suggested by swampland conjecture. The well-known no-go theorem for topologies of horizon except two sphere is avoided by taking into account the Casimir energy, which violate the dominant energy condition, in the energy-momentum tensor.

Presenter: KIMURA, Hayate

Session Classification: parallel session B

Contribution ID: **44** Type: **not specified**

Realising Dark Matter and PTA via Dark Branes

Wednesday, February 19, 2025 3:40 PM (20 minutes)

In this work we propose a setup for the origin of dark matter based on spacetime with a warped extra dimension and three branes: the Planck brane, the TeV brane and a dark brane, at a (sub)-GeV scale. The Standard Model is localized in the TeV brane, thus solving the Higgs hierarchy problem, while the dark matter χ, a Dirac fermion, is localized in the dark brane. The dark matter has only gravitational interactions with the Standard Mode and we show that it can easily reproduce the thermal relic density by annihilations into radions and avoid direct detection experiments. The dark brane comes with a conformal sector confining at a 1st order phase transition generating a stochastic gravitational waves background which can accommodate the recent NANOGrav signal. A region in the parameter space of dark matter and radion masses is selected.

Presenter: KOUTROULIS, Fotis

Session Classification: parallel session B

Contribution ID: **45** Type: **not specified**

Minimal dark matter in SU(5) grand unification

Wednesday, February 19, 2025 4:30 PM (20 minutes)

Minimal dark matter is an attractive candidate for dark matter because it is stabilized without the need to impose additional symmetries. It is known that the mass of the SU(2)L quintuplet fermion dark matter is predicted to be around 14 TeV, based on the thermal production mechanism. In this work, we embed the quintuplet dark matter within non-supersymmetric SU(5) grand unified theories. We find that two pairs of colored sextet fermions are required at the O (1-10) TeV scale to achieve gauge coupling unification, with the unification scale near the reduced Planck scale. These colored sextet fermions become metastable because their interactions are suppressed by the unification scale. Our model can be tested through comprehensive searches for colored sextet fermions in collider experiments, as well as through indirect and direct detection methods for minimal dark matter.

Presenter: TOMA, Takashi

Session Classification: parallel session B

Contribution ID: **46** Type: **not specified**

Phenomenology of Neutrino-Dark Matter Interaction in DSNB and AGN

Wednesday, February 19, 2025 4:50 PM (20 minutes)

We introduce a neutrino-scalar dark matter (DM) ν-ϕ interaction and consider Diffuse Supernova Neutrino Background (DSNB) and Active Galactic Nuclei (AGN) representing distinctive neutrino sources. We focus on interaction mediated by a heavy fermionic particle F and investigate the attenuation of neutrino fluxes from these sources. We model the unscattered neutrino flux from DSNB via core-collapse supernova (CCSN) and star-formation rate (SFR), then use the DUNE experiment to set limits on DM-neutrino interaction. For AGNs, NGC 1068 and TXS 0506+056 where the neutrino carries energy above TeV, we select the kinematic region m^2_F ≫ E_ν m_ϕ ≫ m^2_ϕ such that the νϕ scattering cross section features an enhancement at high energy. We investigate the constraint on m_ϕ and scattering cross section by including DM density spikes at center of AGNs and computing the neutrino flux at IceCube, where the ϕϕ* annihilation cross section is implemented to obtain the saturation density of the spikes.

Presenter: TSENG, Po-Yen

Session Classification: parallel session B

Contribution ID: **47** Type: **not specified**

Composite asymmetric dark matter with a dark photon portal: Multi-Messenger tests

Wednesday, February 19, 2025 5:10 PM (20 minutes)

Composite asymmetric dark matter (ADM) is the framework that naturally explains the coincidence of the baryon density and the dark matter density of the Universe. Through a portal interaction sharing particle-antiparticle asymmetries in the Standard Model and dark sectors, dark matter particles, which are dark-sector counterparts of baryons, can decay into antineutrinos and dark-sector counterparts of mesons (dark mesons) or dark photon. Subsequent cascade decay of the dark mesons and the dark photon can also provide electromagnetic fluxes at late times of the Universe. We derive constraints on the lifetime of dark matter decay in the composite ADM scenario from the astrophysical observations of the e+, e-, and ɣ-ray fluxes. The constraints from cosmic-ray positron measurements by AMS-02 are the most stringent at ⊠2 GeV: a lifetime should be larger than the order of 1026 s, corresponding to the cutoff scale of the portal interaction of about 108 – 109 GeV. We also show the importance of neutrino observations with Super-Kamiokande and Hyper-Kamiokande, which give conservative bounds.

Presenter: KUWAHARA, Takumi

Session Classification: parallel session B

Contribution ID: **48** Type: **not specified**

Sterile neutrino dark matter production in lepton asymmetric universe and its observational implications

Thursday, February 20, 2025 1:30 PM (20 minutes)

Sterile neutrino with masses of the keV scale is a fascinating candidate for dark matter. In particular, in the presence of significant lepton asymmetry in the standard model neutrino sector in the early universe, resonantly produced sterile neutrinos can explain all dark matter consistent with all the observational constraints. Such a large lepton asymmetry has also been suggested by recent observation of the Helium-4 abundance in the metal-poor galaxies. In this talk, we revisit the comprehensive analysis of the allowed parameter region for the resonant production scenario of sterile neutrino DM. Furthermore, we also show that such a significant lepton asymmetry can be realized within the framework of Affleck-Dine leptogenesis, which is based on minimal supersymmetric standard model. In our setup, the AD scalar with leptonic charge forms a non-topological solitons (Q-balls) that eventually dominate the energy density of the universe before decaying into a lepton-asymmetric thermal plasma.
Since the Q-ball decay process is sufficiently instantaneous, scalar-induced GWs is significantly enhanced at the sudden decay of Q-balls. In the last part of the presentation, we show the improved estimate of the GWs at such a sudden transition from Q-ball dominated era to radiation-dominated era.
This presentation is based on arXiv:2402.11902.

Presenter: KASAI, Kentaro

Session Classification: parallel session A

Contribution ID: **49** Type: **not specified**

DM relic abundance via multi-Higgs production in the early universe

It is widely believed that parameter space for Higgs-portal dark matter which achieves the relic abundance through the thermal freeze-out is already tightly constrained. In this talk, we propose a novel scenario that the multiple Higgs production dramatically change this picture. As a result, the relic abundance of DM can be achieved by heavy Higgs-portal DM of m_χ $gtrsimcalO(1)$ TeV in the same way with those for usually considered weakly interacting massive particle models.

Presenter: ENOMOTO, Seishi

Session Classification: parallel session A

Contribution ID: **50** Type: **not specified**

New EDM bounds for electroweak baryogenesis with the minimal setup for CP violation in the extended Higgs model

Thursday, February 20, 2025 1:50 PM (20 minutes)

Electroweak baryogenesis is a promising baryogenesis scenario, which can be tested in various future experiments.
In the mechanism of electroweak baryogenesis, new sources of the CP violation are needed to generate the baryon asymmetry of the Universe.
This new CP violation can be explored in the current and future electric dipole moment (EDM) experiments.
In this talk, we classify the CP violation in the extended Higgs models and find a crucial CP phase for electroweak baryogenesis.
We discuss baryogenesis by this phase and show the unavoidable bounds on the EDMs, which would be reached in future experiments.

Presenter: MURA, Yushi

Session Classification: parallel session A

Contribution ID: **51** Type: **not specified**

A new mechanism for leptogenesis in three-Higgs-doublet models

Thursday, February 20, 2025 3:00 PM (20 minutes)

In standard leptogenesis, several conditions must be satisfied to produce the observed baryon asymmetry: weak wash-out, CP violation in the neutrino Yukawa couplings, and a heavy Majorana mass.
We propose a new mechanism for leptogenesis that relaxes these conditions by employing three-Higgs-doublet models. The non-thermal decay of an additional heavy Higgs generates a charge asymmetry, which remains conserved in the early universe. This asymmetry is subsequently converted into a lepton asymmetry through thermal processes involving neutrino Yukawa interactions.
Our results indicate that the Majorana mass scale can be reduced to as low as 10^5GeV.

Presenter: WATANABE, Hidenaga

Session Classification: parallel session A

Contribution ID: **52** Type: **not specified**

Leptogenesis and Neutrinoless Double-Beta Decay

Thursday, February 20, 2025 3:20 PM (20 minutes)

We revisit the thermal leptogenesis based on the Type I seesaw mechanism and discuss the constraints from future neutrino experiments. Taking the flavor effects into account, we study the influence of the Majorana phases and the effective neutrino Majorana mass for neutrinoless double-beta decay. We present the lower bounds of the right-handed neutrino mass on a plane consisting of the lightest neutrino mass and the effective neutrino Majorana mass.

Presenter: YOKOYAMA, Tatsuya

Session Classification: parallel session A

Contribution ID: **53** Type: **not specified**

Leptogenesis in the presence of density perturbations

Thursday, February 20, 2025 3:40 PM (20 minutes)

I point out a new effect on the freeze-out process of heavy particles induced by density perturbations in the early universe.
Already at moderately large density perturbations $\delta T/\bar{T} \sim 10^{-2}$, this effect cannot be captured by linear perturbation theory.
I illustrate this effect with leptogenesis and discuss phenomenological implications.
I consider the simplest case of leptogenesis
and include only the decays and inverse decays of heavy neutrinos
in the presence of density perturbations.
As a result, I found that perturbations change
the freeze-out values of the lepton asymmetry,
and increase the spatial average of the asymmetry.
Furthermore, constraints on the mass of heavy neutrinos
become relaxed in the presence of perturbations
compared to the case without perturbations,
which is due to a beyond-linear effect caused by the
exponential decoupling of heavy neutrinos from the thermal bath.

Presenter: TAKADA, Rin

Session Classification: parallel session A

Contribution ID: **54** Type: **not specified**

Flavored leptogenesis in Scotogenic models

Thursday, February 20, 2025 4:30 PM (20 minutes)

Flavor effect in leptogenesis is an important effect that can potentially change the baryon asymmetry by up to an order of magnitude.
The scotogenic model proposed by Ernest Ma is an attractive and minimally extended model for producing small neutrino masses through radiative corrections in the dark matter sector.
It is also known that the scotogenic model can explain the baryon asymmetry of the Universe via low-scale leptogenesis.
In this research, We calculated the baryon asymmetry in scotogenic model taking into consideration flavor effect.

Presenter: SEKIKAWA, Yurika

Session Classification: parallel session A

Contribution ID: **55** Type: **not specified**

Thermal leptogenesis in SO(10)×U(1) GUT

Thursday, February 20, 2025 4:50 PM (20 minutes)

In this study, we show that thermal leptogenesis is successful in the natural SO(10) GUT.
When lepton flavor effects are added to thermal leptogenesis, the second-lightest right-handed neutrino contribute non-negligibly. Compared to the mass of the right-handed neutrino predicted by the symmetry of the natural SO(10) GUT, that obtained in this study is about six times smaller than that of the lightest right-handed neutrino contribution. Furthermore, the mass of the left-handed neutrino, determined by the same symmetry, is also predicted to be about 1/6.

Presenter: SHIBATA, Kei

Session Classification: parallel session A

Contribution ID: **56** Type: **not specified**

The time evolution of lepton numbers, Majorana (type) phases and the connection to CP violation for leptogenesis

Thursday, February 20, 2025 5:10 PM (20 minutes)

The time evolution of lepton numbers of Majorana neutrinos are sensitive to neutrino masses , the mixing angles , and CP violation at low energy including Majorana phases and Dirac Kobayashi Maskawa type phase. This implies one can theoretically reconstruct all the elements of the effective Majorana mass matrix at low energy using the time evolution of lepton numbers. In this talk, we diagonalize the 2 × 2 effective Majorana matrix for two generations of the active Majorana neutrinos and express a Majorana phase, the two neutrinos masses, and a mixing angle in terms of the elements of the mass matrix. Then by assuming the origin of the effective Majorana mass matrix comes from type I seesaw model with two gauge singlet neutrinos, we have derived the relation of the single Majorana phase at low energy and two CP violating phases relevant for leptogenesis by drawing the triangles for the elements of the mass matrix in the complex plane which shows the contribution of each singlet neutrino to the elements of the effective Majorana mass matrix.
The talk is based on arXiv:2212.00142v4[hep-ph] 27 Dec 2024.
Nicholas J. Benoit, Yuta Kawamura, Saki Hamada, Takuya Morozumi, Yusuke Shimizu, Kei Yamamoto

Presenter: MOROZUMI, Takuya

Session Classification: parallel session A

Contribution ID: **57** Type: **not specified**

Lepton Flavor Violating Decay of True Muonium

Thursday, February 20, 2025 1:30 PM (20 minutes)

Lepton Flavor Violation (LFV) serves as a crucial probe into physics beyond the Standard Model. To identify the new particles behind LFV, it is important to search for various types of LFV processes, because the LFV mediators indirectly appear in most of LFV processes.
In this study, we propose a new LFV process, the decay of a muon-antimuon bound state into an electron-antimuon (or positron-muon) pair. We calculate the decay rate with scalar-, vector-, and dipole-type operators. Furthermore, we evaluate the discovery potential in future experiments by comparing the results with existing experimental constraints.

Presenter: MINATO, Ryotaro

Session Classification: parallel session B

Contribution ID: **58** Type: **not specified**

Axion detection with quantum Hall effect

Thursday, February 20, 2025 1:50 PM (20 minutes)

A detailed examination of the plateau transition in the quantum Hall effect reveals the presence of axion influence. In quantum Hall effect experiments, strong magnetic fields are used, and microwaves generated by axions from the surrounding metallic walls are emitted. These microwaves are absorbed by localized electrons, causing them to transition to a delocalized state and contribute to the current. This effect impacts the Hall conductivity. When the Fermi energy is in the localized state of electrons, the Hall conductivity remains constant, forming a plateau. However, when the electrons are in the delocalized state, the Hall conductivity changes, leading to a plateau transition. The presence of axion-induced microwaves affects this plateau transition. Therefore, by carefully re-examining the plateau transition, we can observe the axion's influence and demonstrate that its mass is 10^{-5} eV

Presenter: IWAZAKI, Aiichi

Session Classification: parallel session B

Contribution ID: **59** Type: **not specified**

High frequency gravitons from inflation

Thursday, February 20, 2025 2:10 PM (20 minutes)

We show that gravitons are efficiently produced through various processes during reheating. The detection of ultra high frequency stochastic gravitational waves can directly determine the inflaton mass, decay rate etc.

Presenter: NAKAYAMA, Kazunori

Session Classification: parallel session B

Contribution ID: **60** Type: **not specified**

Impact of the Electroweak Weinberg Operator on the Electric Dipole Moment of Electron

Thursday, February 20, 2025 3:00 PM (20 minutes)

The electric dipole moments (EDM) of electron, an observable sensitive to CP violation, is expected to plobe physics beyond the Standard Model (BSM) at TeV scale due to significant improvements in experimental precision. In this study, we evaluated the CP-violating dimension-6 operator for electroweak bosons (the electroweak Weinberg operator) generated at the two-loop level by CP-violating Yukawa interactions involving BSM fermions and scalars in a form independent of scalar particles. We calculated the contribution of this operator to the electron EDM. when the scalar is a BSM scalar,this contribution represents a new 3-loop effect. In contrast, when the scalar is the SM Higgs, this contribution becomes a higher order correction to the 2-loop contribution of the Barr-Zee diagram. We examined the significance of this contribution and suggest that the 3-loop contributions to the electron EDM from BSM models could be tested in future experiments. We examined the significance of this contribution and suggest that the 3-loop contributions to the electron EDM induced by BSM models, such as the dark matter model with electroweak interacting massive fermions, could be tested in future experiments.

Presenter: OGAWA, Kiyoto

Session Classification: parallel session B

Contribution ID: **61** Type: **not specified**

Constraints on Trilinear Higgs Couplings Including One-loop Correction in Nearly Aligned Higgs Models

Thursday, February 20, 2025 3:20 PM (20 minutes)

Although the Higgs boson has been discovered, the couplings between the Higgs boson and Standard Model (SM) particles may deviate from the predictions of the SM. Such deviations can be realized by extending the SM. One possible extension involves the introduction of an extended Higgs model, which extends the Higgs sector. Among extended Higgs models, the nearly aligned Higgs model, characterized by a single classical field, features a Higgs potential whose shape varies depending on the specific model. Classifying models based on the shape of their Higgs potentials provides an effective method for scrutinizing multiple models through high-precision measurements of the trilinear Higgs coupling.
In this study, we calculate the trilinear Higgs coupling, including one-loop corrections from the top quark and new particles, for several representative models. The parameters of these models, derived from the trilinear Higgs couplings, are constrained by expected measurements such as the High-Luminosity LHC and the International Linear Collider. This presentation reports on results from work in progress.

Presenter: OHZAWA, Shuhei

Session Classification: parallel session B

Contribution ID: **62** Type: **not specified**

New Constraints on Gauged U(1)Lμ-Lτ Models via Z-Z' Mixing

Thursday, February 20, 2025 3:40 PM (20 minutes)

Models based on a $U(1)_{L_\mu - L_\tau}$ gauge symmetry can explain the discrepancy between the measured value and theoretical prediction of the muon anomalous magnetic moment. Based on the latest experimental results, we revisit the analysis of neutrino mass matrix structures in minimal $U(1)_{L_\mu - L_\tau}$ models where the $U(1)_{L_\mu - L_\tau}$ symmetry breaking is caused by a single scalar field. Due to the charge assignment of the scalar field, each model predicts a unique structure of the neutrino mass matrix, which demands non-trivial relations among neutrino mass and mixing parameters. We find that the model called type $\mathbf{2}_{+1}$, which features an $SU(2)_L$ doublet scalar Φ_{+1} with the $U(1)_{L_\mu - L_\tau}$ charge $+1$ and the hypercharge $+1/2$ and predicts the $\mathbf{B_3}$ texture structure, is marginally acceptable under the current neutrino oscillation data and cosmological observation. When the $U(1)_{L_\mu - L_\tau}$ gauge symmetry is broken by the vacuum expectation value of the standard model non-singlet representation such as Φ_{+1}, there are additional contributions to flavor-changing meson decay processes and atomic parity violation via mixing between the Z boson and the $U(1)_{L_\mu - L_\tau}$ gauge boson Z'. We newly evaluate the model-dependent constraints on the model and find that the type $\mathbf{2}_{+1}$ model is robustly ruled out. The model is extended to have an additional vacuum expectation value of a standard model singlet scalar in order to avoid the stringent constraints via the $Z - Z'$ mixing. Finally, we clarify the allowed range of the ratio of these vacuum expectation values.

Presenter: MIYAO, Coh

Session Classification: parallel session B

Contribution ID: **63** Type: **not specified**

Effective field theory for type II seesaw model –symmetric phase v.s. broken phase–

Thursday, February 20, 2025 4:30 PM (20 minutes)

Effective field theory is an effective approach to parameterizing effects of high energy scale physics in low energy measurements. The two popular frameworks for physics beyond the standard model are the so-called Standard Model Effective Field Theory (SMEFT) and the Higgs Effective Field Theory (HEFT). While the description by the SMEFT deteriorates when the new physics scale is not so high or it participates in spontaneous electroweak symmetry breaking, the HEFT makes use of nonlinear realization of spontaneously broken symmetry in which there are practically no restrictions on the Higgs field as a singlet. In this work we present another framework, called broken phase effective field theory (bEFT), in which we deal directly with mass eigenstate fields after spontaneous symmetry breaking without employing nonlinear realization. We take the type-II seesaw model as an example to demonstrate our approach. By matching the model at tree level to both bEFT and SMEFT, we compare the results for two processes, the Higgs pair production via vector boson fusion at the LHC and the Higgs-strahlung process at the International Linear Collider. We find that the bEFT reproduces the type-II seesaw model more accurately than the SMEFT in the regions where the bare mass of the Higgs triplet becomes close to the electroweak scale.

Presenter: UCHIDA, Yoshiki

Session Classification: parallel session B

Contribution ID: **64** Type: **not specified**

The probability for chiral oscillation of Majorana neutrino in Quantum Field Theory

Thursday, February 20, 2025 4:50 PM (20 minutes)

We derive the probability for chiral oscillation of Majorana neutrinos based on quantum field theory. Since the Hamiltonian under the Majorana mass term does not conserve lepton number, the eigenstates of lepton number change continuously over time. Therefore, the transition amplitude is described by the inner product of the eigenstates of lepton number at the time of the neutrino production and the detection. With the Bogoliubov transformation, we successfully relates the lepton number eigenstates at different times. This method enables us to understand the time variation of lepton number induced by chiral oscillations in terms of transition probabilities. We also present the physical picture that emerges through the Bogoliubov transformation.

Presenter: TAHARA, Tomoharu

Session Classification: parallel session B

Contribution ID: **65** Type: **not specified**

Effects of electroweak phase transition on dark matter relic abundance

Friday, February 21, 2025 9:50 AM (20 minutes)

The true identity of dark matter (DM) is an unsolved problem in physics. Among the various DM candidates, weakly interacting massive particles (WIMP) are attractive because their abundance can be explained thermally. The WIMP abundance can be estimated using the Boltzmann equation, and particle masses at zero temperature are usually adopted. In this study, we take into account the electroweak phase transition, i.e., the particle masses should change with temperature through a varying vacuum expectation value of Higgs. We compare the DM abundance obtained using the conventional calculation method with our results using the temperature-dependent particle masses.

Presenter: IDEGAWA, Chikako

Session Classification: parallel session A

Contribution ID: **66** Type: **not specified**

Completing the perturbative program for cosmological phase transitions

Friday, February 21, 2025 10:10 AM (20 minutes)

Scale hierarchies are required to reliably describe the thermodynamics of cosmological first-order phase transitions using perturbation theory. At finite temperature, such a hierarchy is provided naturally. One can then use this hierarchy to construct a three-dimensional effective field theory (EFT) that systematically includes thermal resummations to all orders.

Using this EFT setup, I discuss completing the perturbative program for equilibrium thermodynamics of cosmological first-order phase transitions by determining the finite-temperature effective potential of gauge-Higgs theories at next-to-next-to-next-to-next-to-leading order (N4LO) [1,2]. This N4LO result is the last perturbative order before confinement renders electroweak gauge-Higgs theories non-perturbative at four-loops. In contrast with non-perturbative lattice results, the perturbative thermodynamic predictions show remarkable agreement. As a direct application for predictions of gravitational waves produced by a first-order transition, this computation provides the final fully perturbative results for the phase transition strength and speed of sound.

[1] A. Ekstedt, P. Schicho, and T. V. I. Tenkanen, DRalgo: A package for effective field theory approach for thermal phase transitions, Comput. Phys. Commun. 288, 108725 (2023), [2205.08815].[2] A. Ekstedt, P. Schicho, and T. V. I. Tenkanen, Cosmological phase transitions at three loops: The final verdict on perturbation theory, Phys. Rev. D 110, 096006 (2024), [2405.18349].

Presenter: SCHICHO, Philipp

Session Classification: parallel session A

Contribution ID: **67** Type: **not specified**

Reheating Process after Axion Inflation

Friday, February 21, 2025 10:30 AM (20 minutes)

In modern cosmology, it is generally assumed that after inflation, the energy of the inflaton is transferred to radiation through a process known as reheating. Axion-like particles (ALPs) have recently emerged as compelling candidates for the inflaton, primarily because their approximate shift symmetry helps preserve the flatness of the inflationary potential.

This study investigates the reheating process within a model where ALPs are coupled to non-Abelian gauge fields via Chern-Simons interactions. As established in preheating analyses, energy transfer occurs resonantly in this scenario, leading to efficient energy conversion. However, any residual inflaton remaining in the universe could potentially re-dominate the energy density over time.

In this talk, I will present how reheating could be completed in this context and discuss its possible implications for the early universe's evolution.

Presenter: TSUJI, Tenta

Session Classification: parallel session A

Contribution ID: **68** Type: **not specified**

QCD axion from chiral gauge theories

Friday, February 21, 2025 9:50 AM (20 minutes)

We present models of axion based on supersymmetric chiral gauge theories. In these models, the PQ symmetry is spontaneously broken by the non-perturbative dynamics of chiral gauge theory. Thanks to supersymmetry, IR dynamics of the models are calculable. We also present an example of a QCD axion model that is compatible with SU(5) grand unification. To avoid the proton decay constraint and a Landau pole of gauge coupling below the Planck scale, the PQ breaking scale is higher than the GUT scale.

Presenter: TAKESHITA, Shonosuke

Session Classification: parallel session B

Contribution ID: **69** Type: **not specified**

How viable is a QCD axion near 10 MeV?

Friday, February 21, 2025 10:10 AM (20 minutes)

There has been an attempt to revive the visible QCD axion at the 10 MeV scale
assuming that it exclusively couples to the first-generation quarks and the electron.
This variant of the QCD axion is claimed to remain phenomenologically viable,
partly due to a clever model construction that induces tree-level pion-phobia and exploits uncertainties inherent in the chiral perturbation theory.
We confront this model with the cosmological domain wall problem, the quality issue
and constraints arising from the electron electric dipole moment.
It is also pointed out that the gluon loop-generated axion-top coupling can provide a very large contribution to rare B-meson decays, such that the present LHCb data for $B^0 \to K^{*0} e^+ e^-$ rule out the model for the axion mass larger than 30 MeV.
There is a strong motivation for pushing the experimental analysis of $B \to K^{(*)} e^+ e^-$ to a lower $e^+ e^-$ invariant mass window, which will conclusively determine the fate of the model, as its contribution to this branching ratio significantly exceeds the Standard Model prediction.

Presenter: XU, Junxuan

Session Classification: parallel session B

Contribution ID: **70** Type: **not specified**

High Quality QCD axion via Electric-Magnetic Duality

Friday, February 21, 2025 10:30 AM (20 minutes)

Axion can solve the strong CP problem dynamically. However, since a global symmetry is expected to be broken explicitly in quantum gravity theory, any extra Peccei-Quinn (PQ) symmetry breaking operator must be suppressed, except for nonperturbative effects of QCD. In this talk, we propose a novel paradigm for the QCD axion with high-quality PQ symmetry on the basis of electric-magnetic duality in the conformal window of a supersymmetric gauge theory. PQ breaking fields emerge in the magnetic theory and possess a large anomalous dimension, which leads to not only generation of an intermediate scale of spontaneous PQ breaking but also significant suppression of explicit PQ symmetry breaking operators. The high PQ quality and the absence of a Landau pole in the color gauge coupling are achieved. We will also show the parameter space to realize the correct abundance of the axion dark matter.

Presenter: NAKAGAWA, Shota

Session Classification: parallel session B

Contribution ID: **71** Type: **not specified**

Two-sided story of sterile neutrinos: production under X-ray limits

Thursday, February 20, 2025 5:10 PM (20 minutes)

Sterile neutrinos are well-motivated and actively searched for hypothetical neutral particles that would mix with the Standard Model active neutrinos. They are considered prime warm dark matter (DM) candidates, typically when their mass is in the keV range, although they can also be hot or cold DM components.
We discuss in detail the characteristics and phenomenology of sterile neutrinos that minimally couple only to active neutrinos and are produced in the evaporation of early Universe primordial black holes (PBHs), a process we called "PBH sterile neutrinogenesis". Contrary to the previously studied sterile neutrino production mechanisms, this novel mechanism does not depend on the active-sterile mixing. The resulting sterile neutrinos have a distinctive spectrum and are produced with larger energies than in typical scenarios. When PBHs matter- dominate before evaporating, the possible coincidence of induced gravitational waves associated with PBH evaporation and astrophysical X- ray observations from sterile neutrinos decays constitutes a distinct signature of our scenario.
In addition, we discuss the possibility of two distinct sterile neutrino populations making up the whole DM energy density in the regions where generating the whole DM density with only one production mechanism is restricted by the X-ray limit.

Presenter: CHEN, Muping

Session Classification: parallel session B

Contribution ID: **72** Type: **not specified**

Memory-Burdened Primordial-Black-Hole Dark Matter probed by Induced Gravitational Waves

Thursday, February 20, 2025 2:10 PM (20 minutes)

Quantum evaporation of a black hole is conventionally studied semiclassically by assuming self-similarity of the black hole throughout the evaporation process. However, its validity was recently questioned, and the lifetime of a black hole is conjectured to be much extended by the memory burden effect. It gives rise to the possibility that the primordial black holes (PBHs) lighter than 10^10 grams are the dark matter in the Universe. To probe such PBH dark matter, we study gravitational waves (GWs) induced by primordial curvature perturbations that produced the PBHs. We find that the PBH dark matter whose initial mass is greater than about 10^7 grams is associated with the high-frequency induced GWs that can be tested by future observations such as Cosmic Explorer. In principle, the scenario can be confirmed by detecting another GW signal from the mergers of PBHs, which leads to extremely high-frequency GWs. On the other hand, the induced GW signals stronger than expected would contradict the dark matter abundance and exclude the memory burden effect.

Presenter: TERADA, Takahiro

Session Classification: parallel session A