KPS 한국물리학회 The Korean Physical Society

DIVISION OF

PARTICLES & FIELDS

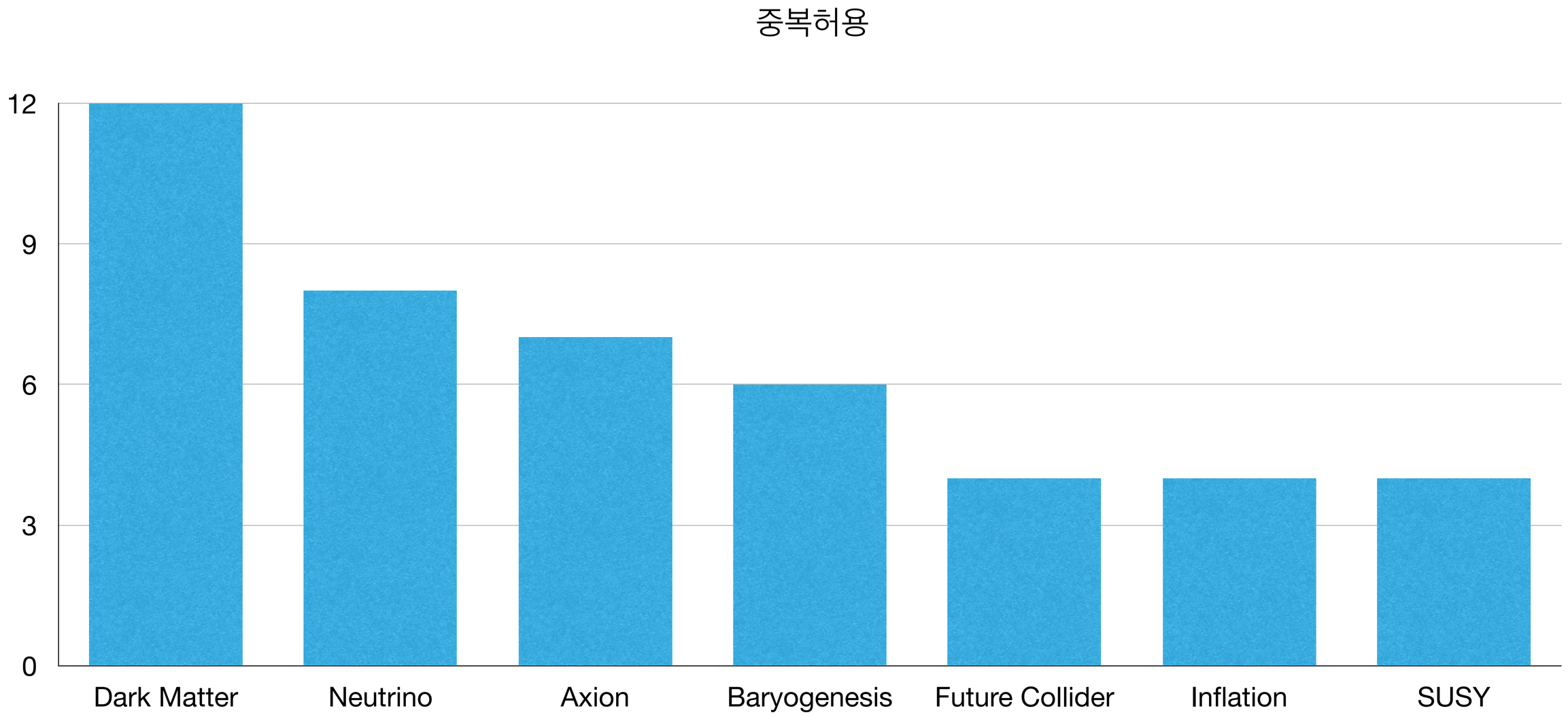
DPF workshop 2024

Particle Phenomenology 2024 Overview

Seodong Shin

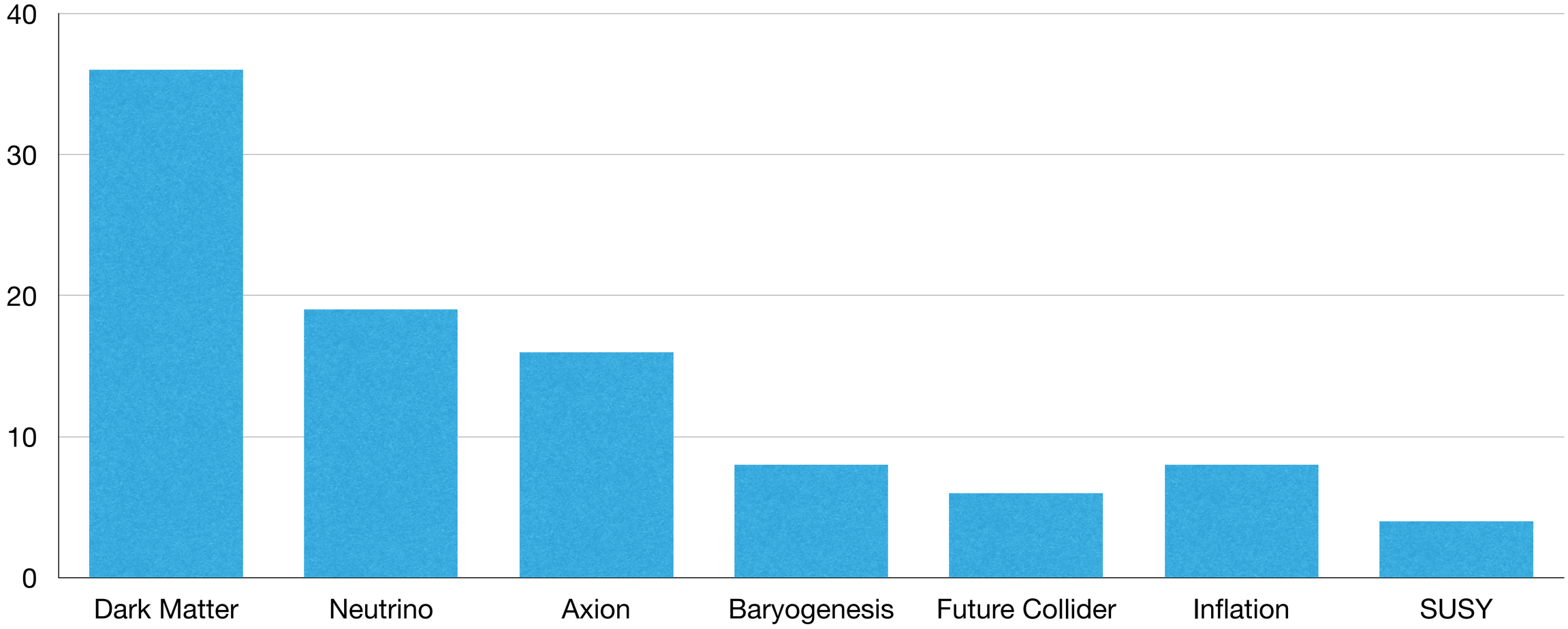
전북대학교 JEONBUK NATIONAL UNIVERSITY

KPS talks in 2024



Papers in 2024

inspirehep “find Korea” (any Korean affiliations) & less than 10 authors & hep-ph



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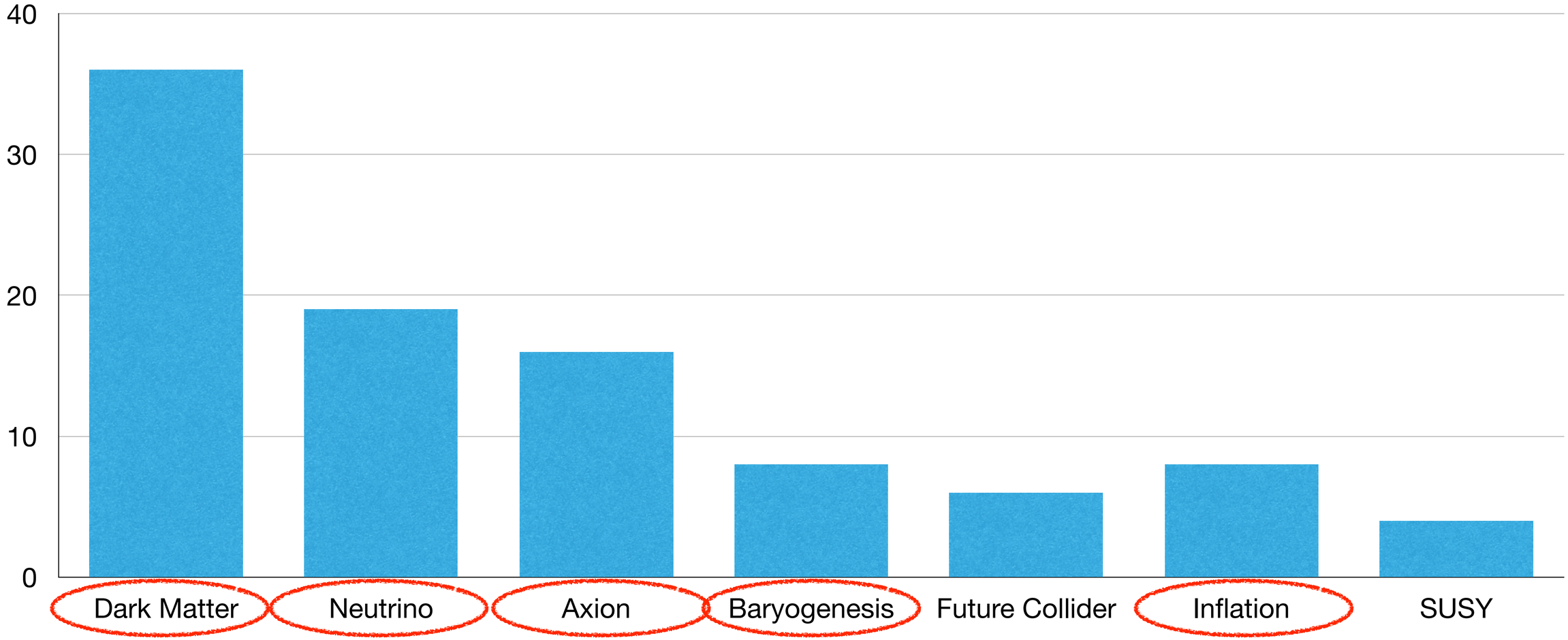

+ Quantum Information / Entanglement

Dark Matter

Key questions

(correlated each other)

- What physical properties does dark matter have?
- How is its relic abundance determined?
- How does it affect cosmological and astrophysical observations?
- How do we observe it?

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  WIMP?

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(Including a complicated version of WIMP)

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i) well-motivated theories

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Axion or ALP

Simplified models (dark xxx)

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Simplified models (dark xxx)

Is dark matter a particle? ⟶ Composite particle? Wavelike? Stellar object like PBH?

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- How do we observe it? Very important!

  Direct detection, Indirect detection, Collider search, Neutrino experiments, New experiments?

Dark Matter

KPS meetings

Stable dark matter from Pauli blocking in the degenerate fermion background with Quantum Field Theory
조정훈 (성균관대 최기영 교수님 학생)

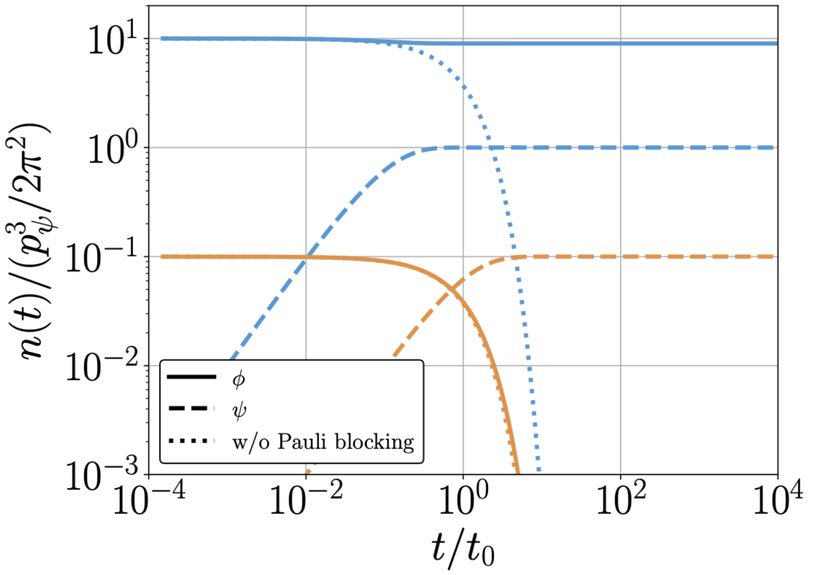
Stable dark matter from Pauli blocking in the degenerate fermion background with Quantum Field Theory

Wonsub Cho (Sungkyunkwan U.), Ki-Young Choi (Sungkyunkwan U. and Korea Inst. Advanced Study, Seoul), Junghoon Joh (Sungkyunkwan U.), Osamu Seto (Hokkaido U.) (Jul 11, 2024)

e-Print: 2407.08229 [hep-ph]

Abstract. We study a mechanism to make dark matter stable based on the Pauli blocking in the fermion background. In the background where fermions occupy the states, the decay of dark matter to those final states is not allowed, as a result, DM becomes stable. We derive the evolution equations of the distribution function in the quantum field theory and compare it with the Boltzmann equation. We apply this mechanism to a realistic model of neutrino and dark matter.

Real scalar DM ϕ decays into fermion pairs $\mathcal{L} \ni \lambda \bar{\psi} \psi \phi$



Neutrino

Key questions (correlated each other)

- Identification of the oscillation parameters: CP violation, Mass hierarchy, θ_{23}, …

- Is neutrino Majorana or Dirac?

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- Is there non-standard (NSI) or self-interactions (SNI) of neutrinos?

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Sterile neutrino? Light dark sector particles? …

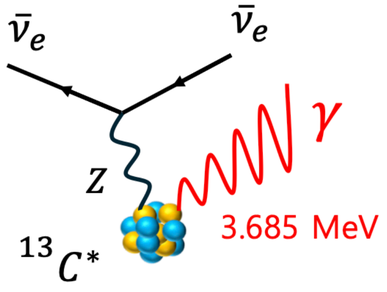
Reactor antineutrino flux from neutrino - 13C neutral current interactions 박민과 (전북대 석사 2년차)

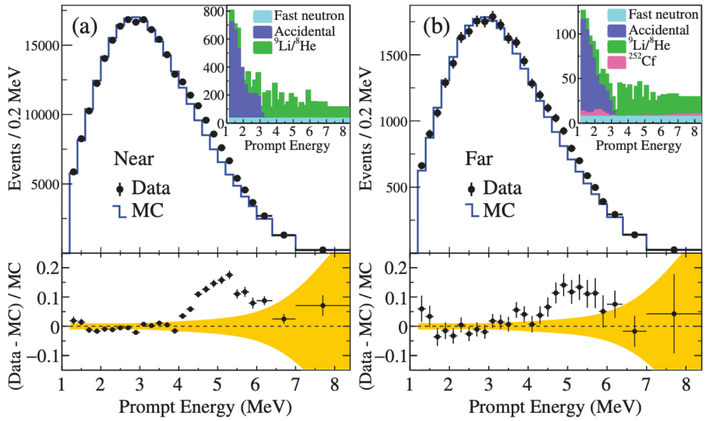
Revisiting Reactor Anti-Neutrino 5 MeV Bump with ^{13}C Neutral-Current Interaction

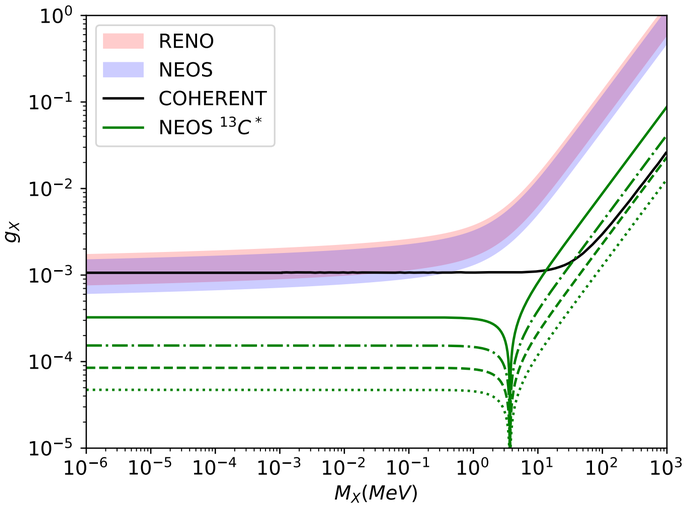
Pouya Bakhti (Jeonbuk Natl. U.), Min-Gwa Park (Jeonbuk Natl. U.), Meshkat Rajaee (Jeonbuk Natl. U.), Chang Sub Shin (Chungnam Natl. U. and IBS, Daejeon, CTPU and IBS, Daejeon and Korea Inst. Advanced Study, Seoul), Seodong Shin (Jeonbuk Natl. U. and IBS, Daejeon, CTPU and IBS, Daejeon)

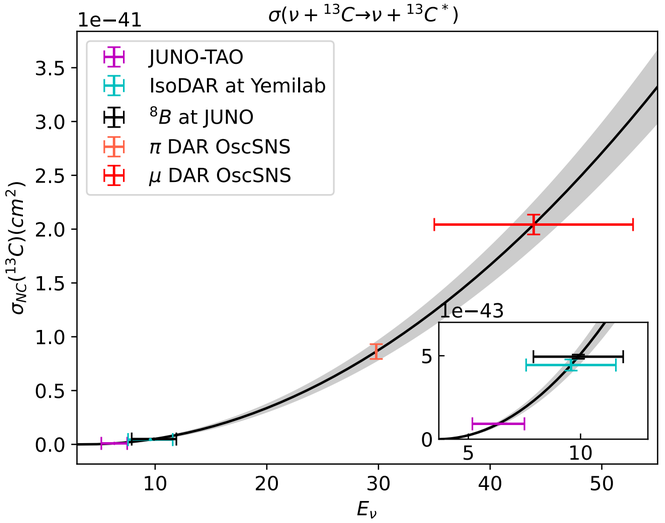
(May 14, 2024)

e-Print: 2405.08724 [hep-ph]









Local excesses do exist: 5 MeV bump ~ 4σ from HM

Sterile ν with NSI? No!

Applicable to other neutrinos

Axion

Key questions

- Axions resolving the strong CP problem
- More questions on the QCD axion solving the strong CP problem
- Axion dark matter and dark radiation?
- Axion-like particle (ALP) searches

Axion

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  KSVZ? DFSZ? Predictions for EDM? Axion Quality Problem? Global Symmetry?
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  Wave-like dark matter, Axion star, Axion mini cluster, Various direct detection ideas, …

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  Effect of ALP production on stellar evolution, cosmic/galactic/stellar magnetic fields, new experiment, …

Axion KPS meetings

2024 KPS Fall Meeting

Tuesday-Saturday, October 22-26, 2024; Yeosu Expo Convention Center

Session Information	B2-pa	Focus: Axion Physics
	Seminar Rm 1	October 23 (Wednesday) 15:30 - 17:06
Chair	신서동	전북대학교

Join the virtual conference >

Presentation No.	Time	Presenter	Title	Add to Wishlist
B2.01	2024-10-23 15:30-15:54	JEONG Kwang Sik	Axions in cosmology	Add to Wishlist
B2.02	2024-10-23 15:54-16:18	YOUN SungWoo	Axion detection: advanced technologies and recent results from IBS-CAPP	Add to Wishlist
B2.03	2024-10-23 16:18-16:42	IM Sang Hui	The EDM inverse problem: Disentangling the UV sources of CP violation and PQ breaking with electric dipole moments	Add to Wishlist
B2.04	2024-10-23 16:42-17:06	SHIN Chang Sub	Axion Quality Problem	Add to Wishlist

Warmhole Induced ALP Dark Matter 정동연 (연세대 박성찬 교수님 학생)

Wormhole-Induced ALP Dark Matter

Dhong Yeon Cheong,[a] **Koichi Hamaguchi,**[b,c] **Yoshiki Kanazawa,**[b] **Sung Mook Lee,**[d*] **Natsumi Nagata,**[b] **Seong Chan Park** [a,e*]

Abstract: Non-perturbative gravitational effects induce explicit global symmetry breaking terms within axion models. These exponentially suppressed terms in the potential give a mass contribution to the axion-like particles (ALPs). In this work we investigate this scenario with a scalar field charged under a global $U(1)$ symmetry and having a non-minimal coupling to gravity. Given the exponential dependence, the ALP can retain a mass spanning a wide range, which can act as a dark matter component. We specify pre-inflationary and post-inflationary production mechanisms of these ALPs, with the former from the misalignment mechanism and the latter from both the misalignment and cosmic-string decay. We identify the allowed parameter ranges that explain the dark matter abundance for both a general inflation case and a case where the radial mode scalar drives inflation, each in metric and Palatini formalisms. We show that the ALP can be the dominant component of the dark matter in a wide range of its mass, $m_a \in [10^{-21}$ eV, TeV], depending on the inflationary scenario and the $U(1)$ breaking scale. These results indicate that ALPs can be responsible for our dark matter abundance within a setup purely from non-perturbative gravitational effects.

Baryogenesis

Key questions

- What is the origin of the matter-antimatter asymmetry?
- How can we test the model of baryogenesis?
- Can we have a deeper understanding with other cosmological variables?
- Systematic treatment of the evolution of asymmetries

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  Baryon to Dark Matter ratio, Neutrino masses & CP phase, Inflation, Dark radiation, …

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- Systematic treatment of the evolution of asymmetries

  Coupled Boltzmann equations, Nonequilibrium QFT, …

Baryogenesis

KPS meetings

Neutrino portal Affleck-Dine Baryogenesis 이창현 (충남대 신창섭 교수님 학생, 현 충남대 연구원)

Dynamical generation of the baryon asymmetry from a scale hierarchy

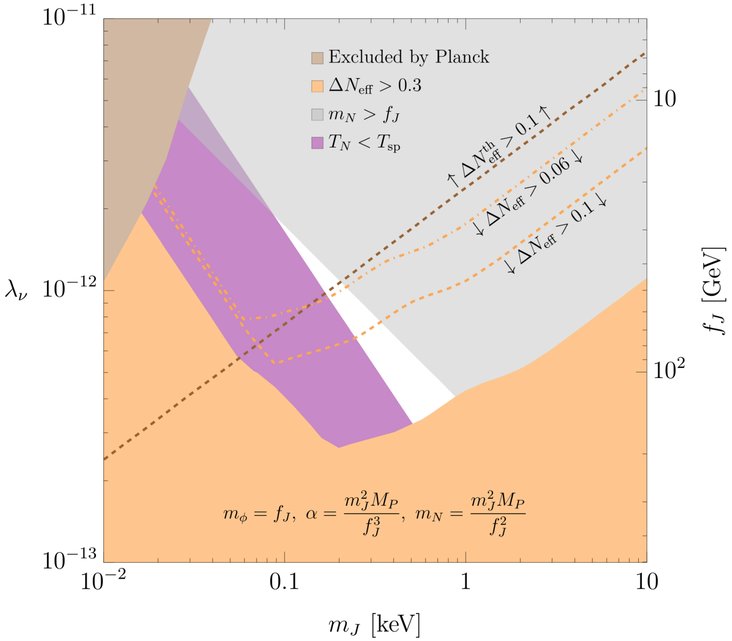
Jae Hyeok Chang (Fermilab and Illinois U., Chicago), Kwang Sik Jeong (Pusan Natl. U.), Chang Hyeon Lee (Chungnam Natl. U.), Chang Sub Shin (Chungnam Natl. U.) (Jan 24, 2024)

Published in: *Phys.Rev.D* 110 (2024) 5, 055038 • e-Print: 2401.13734 [hep-ph]

We propose a novel baryogenesis scenario where the baryon asymmetry originates directly from a hierarchy between two fundamental mass scales: the electroweak scale v and the Planck scale M_P, in the form of

$$Y_B \sim \sqrt{\frac{v}{M_P}}\,.$$

This relation straightforwardly gives the observed baryon yield today Y_B, which can be a hint for underlying fundamental physics. We provide an example of baryogenesis models that yield this relation. Our model is based on the neutrino-portal Affleck-Dine mechanism, which generates the asymmetry of the Affleck-Dine sector during the radiation-dominated era and subsequently transfers it to the baryon number before the electroweak phase transition. The observed baryon asymmetry is then a natural outcome of this scenario. The model is testable as it predicts the existence of a Majoron with a keV mass and an electroweak scale decay constant. The impact of the relic Majoron on the effective number of neutrinos ($\Delta N_{\rm eff}$) can be measured through near-future cosmic microwave background observations.



Inflation

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- What is the natural solution of the horizon & flatness problems of the Universe?
- What are possible observables for the inflationary scenarios?
- What is the microscopic theory of inflation?
- Preheating and reheating history of the Universe?

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  Interaction to the SM particles, Gravitational production, Resonant production, …

PQ inflation at the pole 아드리아나 멘카라 (중앙대 이현민 교수님 학생, 현 DESY 포스닥)

Inflation models with Peccei–Quinn symmetry and axion kinetic misalignment

Hyun Min Lee (Chung-Ang U.), Adriana G. Menkara (Chung-Ang U.), Myeong-Jung Seong (Chung-Ang U.), Jun-Ho Song (Chung-Ang U.) (Aug 30, 2024)

Published in: *Eur.Phys.J.C* 84 (2024) 12, 1260 • e-Print: 2408.17013 [hep-ph]

We propose a consistent framework with the $U(1)$ Peccei-Quinn (PQ) symmetry for obtaining the initial condition for axion kinetic misalignment from inflation. We introduce a PQ complex scalar field and an extra Higgs doublet, which are conformally coupled to gravity, and three right-handed neutrinos for the seesaw mechanism. In the DFSZ type scenarios for the axion, we obtain the PQ anomalies from the Standard Model quarks carrying nonzero PQ charges in some of two Higgs doublet models, solving the strong CP problem by the QCD potential for the axion. Assuming that the PQ symmetry is explicitly violated in the scalar potential by quantum gravity effects, we show that a sufficiently large initial axion velocity can be obtained before the QCD phase transition while avoiding the axion quality problem. As inflation is driven by the radial distance from the origin in the space of scalar fields close to the pole of the kinetic terms in the Einstein frame, we obtain successful inflationary predictions and set the initial axion velocity at the end of inflation. Focusing on the pure PQ inflation with a small running quartic coupling for the PQ field, we discuss the post-inflationary dynamics for the inflaton and the axion. As a result, we show that a sufficiently high reheating temperature can be obtained dominantly from the Higgs-portal couplings to the PQ field, while being consistent with axion kinetic misalignment, the stability for the Higgs fields during inflation and the non-restoration of the PQ symmetry after reheating.

Quantum Information / Entanglement

KPS 2023 Spring meeting Focus session & KPS 2024 Fall meeting Pioneer session

2023 KPS Spring Meeting

Wednesday-Friday, April 19-21, 2023; Daejeon Convention Center & IBS SCC

Session Information	ⒺA16-pa	Focus: Synergy between High Energy Phenomenology and Quantum Information I
	IBS SCC Auditorium	April 19 (Wednesday) 12:00 - 13:12
Chair	박명훈	서울과학기술대학교

Join the virtual conference >

Presentation No.	Time	Presenter	Title	Add to Wishlist
A16.01	2023-04-19 12:00-12:24	GONCALVES Dorival	Entanglement and Bell Inequalities at the LHC with Top Quark Pair Production	Add to Wishlist
A16.02	2023-04-19 12:24-12:48	BAE Joonwoo	Entanglement Theory : Structure and Certification	Add to Wishlist
A16.03	2023-04-19 12:48-13:12	PARK Kyungdeock	Quantum Machine Learning: Opportunities and Challenges	Add to Wishlist

2023 KPS Spring Meeting

Wednesday-Friday, April 19-21, 2023; Daejeon Convention Center & IBS SCC

Session Information	ⒺB16-pa	Focus: Synergy between High Energy Phenomenology and Quantum Information II
	IBS SCC Auditorium	April 19 (Wednesday) 14:00 - 15:12
Chair	배준우	한국과학기술원

Join the virtual conference >

Presentation No.	Time	Presenter	Title	Add to Wishlist
B16.01	2023-04-19 14:00-14:24	MITARAI Kosuke	Constructing machine learning models with quantum computers	Add to Wishlist
B16.02	2023-04-19 14:24-14:48	ARAZ Jack	Theory-driven Quantum Machine Learning for HEP	Add to Wishlist
B16.03	2023-04-19 14:48-15:12	BARR Alan James	Exploring quantum foundations with gauge bosons	Add to Wishlist

2024 KPS Fall Meeting

Tuesday-Saturday, October 22-26, 2024; Yeosu Expo Convention Center

Session Information	F2-pa	Pioneer: High Energy Quantum Entanglement I
	Seminar Rm 1	October 24 (Thursday) 14:24 - 15:36
Chair	신서동	전북대학교

Presentation No.	Time	Presenter	Title	Add to Wishlist
F2.01	2024-10-24 14:24-15:00	PARK Inkyu	A brief introduction to quantum entanglement in high energy physics	Add to Wishlist
F2.02	2024-10-24 15:00-15:36	PARK Myeonghun	Quantum Entanglement and the Higgs Boson at the LHC	Add to Wishlist

2024 KPS Fall Meeting

Tuesday-Saturday, October 22-26, 2024; Yeosu Expo Convention Center

Session Information	ⒺG2-pa	Pioneer: High Energy Quantum Entanglement II
	Seminar Rm 1	October 24 (Thursday) 16:24 - 17:36
Chair	김태정	한양대학교

Presentation No.	Time	Presenter	Title	Add to Wishlist
G2.01	2024-10-24 16:24-17:00	JUNG Andreas	Unraveling the mysteries of Quantum Mechanics with top quarks	Add to Wishlist
G2.02	2024-10-24 17:00-17:36	SIMPSON Ethan Lewis	Entangled in Tops: How we turned ATLAS into the world's largest quantum information experiment	Add to Wishlist

Quantum Information / Entanglement

Hybrid quantum-classical approach for combinatorial problems at hadron colliders

Jacob L. Scott (Kansas U.), Zhongtian Dong (Kansas U.), Taejoon Kim (Arizona State U.), Kyoungchul Kong (Kansas U.), Myeonghun Park (Korea Inst. Advanced Study, Seoul and Seoultech) (Oct 29, 2024)

e-Print: 2410.22417 [hep-ph]

Transmon Qubit constraints on dark matter-nucleon scattering #15

Anirban Das (Seoul Natl. U., Dept. Phys. Astron.), Noah Kurinsky (SLAC and KIPAC, Menlo Park), Rebecca K. Leane (SLAC and KIPAC, Menlo Park) (Apr 30, 2024)

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Conclusions