Axions in Japan

Report of Contributions

https://indico.ipmu.jp/e/axions_japan

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

Gravitational waves from self-interacting axion clouds around rotating black holes

Monday 10 November 2025 14:20 (20 minutes)

Black hole superradiance can lead to the formation of clouds of ultralight bosons such as axions. These clouds are expected to be detected through gravitational wave observations, but reliable predictions require a detailed understanding of their evolution. We investigate the dynamics of axion clouds including the effects of self-interaction, with particular emphasis on the role of mode couplings with multiple levels. We present the resulting phenomena and discuss their potential impact on gravitational wave signals.

Presenter: TAKAHASHI, Takuya

Session Classification: Parallel session - Gravity I

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

Strong backreaction of gauge quanta produced during inflation and the sourced GWs

Monday 10 November 2025 14:00 (20 minutes)

In this report, I will introduce our recent studies about the axion-gauge system during inflation, mainly focusing on the strong backreaction region. With a linear axion potential, we found that a steeper slope can enhance the gauge quanta production, while a larger coupling cannot increase it. We then apply this result to a realistic model with cosine axion potential, finding the quantum fluctuation can limit the max GW spectrum.

Presenter: HE, Jian-Feng

Session Classification: Parallel session - Gravity I

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

Multi-Axion Bosenovae and Sequential Axion Emissions

Monday 10 November 2025 14:00 (20 minutes)

Axion particles can form gravitationally bound condensates known as axion stars. In the presence of self-interactions their collapse can trigger axion bosenovae —transient events accompanied by bursts of relativistic particle emission. We investigate such phenomena in systems composed of multiple axion fields, which can arise in various extensions of the Standard Model. Using both variational and numerical methods, we analyze the collapse dynamics and develop a framework to estimate collapse times. We explore the possibility of multiple bosenovae, where successive collapse events lead to the depletion and emission of different axion species. Our results provide a self-contained treatment of multi-axion collapse and uncover novel phenomena - time-separated, multi-frequency transients that could distinguish multi-field configurations from single-species axion stars.

Presenter: ARAKAWA, Jason

Session Classification: Parallel session - Cosmology I

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

Core–Halo Relation in Self-Interacting Scalar Field Dark Matter

Monday 10 November 2025 14:20 (20 minutes)

In this talk, I will explore the phenomenology of scalar field dark matter with both attractive and repulsive self-interactions. Using idealized simulations, I analyze the properties of halo cores across a wide range of interaction strengths, from the strongly attractive regime to the Thomas–Fermi limit. The numerical results are compared with analytical predictions for the core mass–size relation and with free-case scalings reported in the literature. I will also examine the core–halo connection across all interaction regimes and discuss how scaling relations vary with the total energy of the system. Finally, I will present the time evolution of the core mass, which exhibits a self-similar growth behavior.

Presenter: N. LOPEZ-SANCHEZ, Jessica

Session Classification: Parallel session - Cosmology I

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

Interfering and Interacting Fuzzy Dark Matter

Monday 10 November 2025 14:40 (20 minutes)

In the standard Fuzzy Dark Matter (FDM) scenario, the dark matter is composed of an ultra-light scalar field with coherence length and wave interference on astrophysical scales. However, scalar fields generically have quartic self-interactions that modify their dispersion relation and the associated evolution of density perturbations. I will begin by presenting the first dedicated analysis of the relationship between wave interference and the evolution due to self-interactions. For warm FDM, density perturbations are unable to grow on the expected self-interaction time scale because of interference effects, instead saturating on the much shorter de Broglie crossing time, with a dependence on the sign of the interaction. I will then introduce the Fuzzy Dark Sector (FDS) as a model extension with multiple interacting fuzzy degrees of freedom that interfere with each other. Remarkably, the FDS can recover a single cutoff scale in cosmology while generating a great diversity of halos at late times. Finally, I will discuss how these interference effects might be observed across a range of astrophysical environments and shed further light on interacting FDM.

Presenter: CAPANELLI, Christian

Session Classification: Parallel session - Cosmology I

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

Toward remote sensing of backward reflection from stimulated axion decay

Tuesday 11 November 2025 14:00 (20 minutes)

We propose a method for remotely detecting backward reflection via induced decay of cold dark matter such as axion in the background of a propagating coherent photon field. This method can be particularly useful for probing concentrated dark matter streams by Earth's gravitational lensing effect. Formulae for the stimulated reflection process and the expected sensitivities in local and remote experimental approaches are provided for testing eV scale axion models using broad band lasers. The generic axion-photon coupling is expected to be explorable up to O(10^-11) GeV and O(10^-22) GeV for the idealized local and remote setups, respectively [1]. We report on the recent developments toward the pilot search.

[1] K. Homma, JHEP 09 (2024) 034 • e-Print: 2312.02005 [hep-ph]"

Presenter: HOMMA, Kensuke

Session Classification: Parallel session - Experiments II

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

A Way of Axion Detection with Mass 10^(−4)eV ~ 10^(−3)eV using Cylinder with Low Electric Conductivity

Tuesday 11 November 2025 14:20 (20 minutes)

A dark matter axion with mass ma induces an oscillating electric field in a cylindrical sample placed under a magnetic field B parallel to the cylinder axis. When the cylinder is made of a highly conductive material, the induced oscillating current primarily dissipates the axion energy at the surface. In contrast, if the cylinder is composed of a material with low conductivity, e.g. σ = 10^(−3)eV, the axion energy is dissipated mainly inside the bulk of the cylinder. Within the QCD axion model, the dissipated power P is estimated as P ≃ 2.8×10^(-28)W g^2 (L/100cm) (10^(−4)eV/ma)(B/10T)^2
(ρa/0.3GeV cm^(−3))(yx^2/(ϵ^2 +y^2)), with parameters y ≡ σ/ma = 10, x ≡ maR ≫ 10, axion mass ma, radius R = 2cm, length L = 100cm, electric permittivity ϵ = 10 and axion energy density ρa. For the coupling constants, we take g(KSVZ) = −0.96 and g(DFSZ) = 0.37. Using an LC circuit tuned to a quality factor Q = 10^6, the signal-to-noise ratio is given by P(Q sqrt(δω tob/2π)/Pt ≃ 10 g^2(ma/10^(−4)eV)^(−3/2) (T/100mK)^(−1)sqrt(tob/60s), where Pt is the thermal noise power at temperature T = 100mK and bandwidth δω = 10^(−6)ma. By choosing appropriate values of conductivity and cylinder radius for example, σ/ma = 10 and ma R ≥ 10, the detection of dark matter axions is feasible in the mass range ma = 10^(−4)eV ~ 10^(−3)eV

Presenter: IWAZAKI, Aiichi

Session Classification: Parallel session - Experiments II

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

Axion dark matter search using quantum sensing of magnons: Estimation of sensitivity for Kittel mode – superconducting qubit hybrid

Tuesday 11 November 2025 14:40 (20 minutes)

Axions can be probed through the interaction between axions and electron spins. By detecting magnons (quantum of collective spin excitation) induced by axions inside a ferromagnetic crystal such as YIG, we can explore the parameter space of axions in the GHz regime. To improve the sensitivity of axion detectors, we must (1) increase the signal (magnons) excited by axions and (2) suppress detector noise. Using a dilution refrigerator, thermal noise can be suppressed to below 50 mK. The noise of conventional axion detectors is limited by the Standard Quantum Limit. This-Standard Quantum Limit can be overcome by quantum sensing of magnons using superconducting qubits. I will present the sensitivity evaluation along with our R&D toward an axion dark matter detector using a superconducting qubit-Kittel mode hybrid system.

Presenter: SINGH SHRESTHA, Yaman

Session Classification: Parallel session - Experiments II

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

Background-Enhanced Axion Force by Axion Dark Matter

Monday 10 November 2025 15:30 (20 minutes)

In this talk, I will discuss the impact of axion dark matter on spin-independent forces between nucleons. Our study shows that when the axion dark matter background is taken into account, the axion-mediated force changes its distance dependence from 1/r^3 to 1/r, and its magnitude is significantly enhanced proportionally to the axion number density. This amplification allows fifth-force experiments—such as Casimir-less setups and torsion balance tests—to place constraints on the axion decay constant several orders of magnitude stronger than previously estimated, across a wide range of axion masses. These results suggest that such experiments are even more sensitive to axion detection than previously understood.

Presenter: CHENG, Yu

Session Classification: Parallel session - Pheno I

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

Electric Dipole Moments From Missed Dark Matter Scattering

Monday 10 November 2025 15:50 (20 minutes)

Axion-like particles are a well-motivated candidate for ultralight dark matter. Because dark matter must be non-relativistic, the effects of its scattering with Standard Model particles are negligible and generally go unnoticed. However, due to the large occupation number of ultralight dark matter, the sum of all scatterings leads to a classical field-like interaction with Standard Model particles. In the case of an axion-like particle, this scattering imparts a parity violating effect. If this
collective scattering with axion-like particles is inserted into the one-loop quantum electrodynamics
diagram, the parity violation imparted by this scattering will convert the anomalous magnetic moment contribution into an electric dipole moment. This contribution is quite large and leads to a prediction inconsistent with precision measurements of the proton and electron electric dipole moments, unless their couplings to the axion-like particles are very weak. As a result, the constraints
on the couplings of axion-like particle dark matter to the electron and proton are improved by as much as eleven and six orders of magnitude, respectively."

Presenter: L. EVANS, Jason

Session Classification: Parallel session - Pheno I

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

Constraints on MeV Axion Models from Kaon Decays with KTeV Data

Monday 10 November 2025 16:10 (20 minutes)

The QCD axion is a compelling mechanism for solving the strong CP problem. Most studies have focused on axion models with a large decay constant, (f_a
\gtrsim10^9 GeV). However, recent work has pointed out that viable axion models may also exist for (f_a\sim1 GeV). In our research, we derive stringent constraints on this axion scenario from kaon
decay measurements.

Presenter: IWAI, Takaya

Session Classification: Parallel session - Pheno I

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

Search for sub-eV ALP via quasi-parallel stimulated resonant photon collision with “coronagraphy”to mitigate background photon based on spatial distribution characteristics

Monday 10 November 2025 16:30 (20 minutes)

The identity of dark matter (DM) remains one of the major mysteries of modern physics. The QCD axion, arising from the Peccei-Quinn mechanism that solves the strong CP problem, is a well-motivated low-mass DM candidate.
The SAPPHIRES collaboration searches for the QCD axion and axion-like particles (ALPs) using two-color, high-intensity, short-pulse lasers [1]. Our approach targets signal photons from stimulated resonant photon-photon scattering via ALP exchange. The dominant background photons, originating from nonlinear photon-atom interactions in optical elements, have been verified to be spatially concentrated near the beam axis, in contrast to the expected distribution of signal photons. Exploiting this spatial distinction, we developed a “coronagraphy”method that introduces an eclipse filter to effectively mitigate background photons while maintaining sensitivity to signal photons. We further acquired data with deliberately degraded spatial overlap of the two beams at the focus and found no statistically significant excess. With this technique, we have achieved the highest laboratory sensitivity to date in the sub-eV mass range. In this presentation, we report the results of this search.
[1] Y. Kirita, A. Kodama, K. Homma, C. Chiochiu, M. Cuciuc, G. Giubega, T. Hasada, M. Hashida, S. Masuno, Y. Nakamiya, L. Neagu, V. Phung, V. Rodrigues, M. Rosu, S. Sakabe, S. Tazlauanu, O, Tesileanu, and S. Tokita, [SAPPHIRES collaboration], “Search for sub-eV axion-like particles in a quasi-parallel stimulated resonant photon-photon collider with “coronagraphy””, JHEP, 06(2025)138”

Presenter: KODAMA, Airi

Session Classification: Parallel session - Pheno I

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

Resolving the QCD Axion Domain Wall Problem with a Light Axion

Monday 10 November 2025 15:30 (20 minutes)

We propose two novel solutions to the domain wall problem of the QCD axion by introducing a massless or light axion that also couples to gluons. The first solution applies when the new axion forms strings after inflation. Due to its mixing with the QCD axion, domain walls of the QCD axion are bounded by these strings and confined into cosmologically safe string bundles. This scenario predicts the existence of such string bundles, which may survive until today and leave observable signatures, such as gravitational waves, cosmic birefringence, and CMB anisotropies. The simultaneous detection of the QCD axion and any of these cosmological signatures would serve as a smoking-gun signal. The second solution assumes a homogeneous initial condition for the new axion. If it is sufficiently light, its potential temporarily induces a bias in the QCD axion potential before the onset of oscillations, rendering the domain walls unstable. In both scenarios, the Peccei-Quinn mechanism remains effective, and the strong CP problem is not reintroduced. We identify the viable parameter regions and discuss the resulting dark matter abundance.

Presenter: MURAI, Kai

Session Classification: Parallel session - Theory I

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

A Step in Flux to Suppress Axion Isocurvature

Monday 10 November 2025 15:50 (20 minutes)

The QCD axion is one of the most compelling dark matter candidates, but faces a stringent isocurvature constraint, which requires a relatively low Hubble scale during inflation. If the axion was heavier than the Hubble scale during inflation, its isocurvature is suppressed and the constraint significantly relaxes. We point out a novel mechanism for achieving this, relying on the topological nature of a monodromy mass for the axion. Such a mass term has an integer coefficient, so it could naturally have been very large during inflation and exactly zero by the time of the QCD phase transition. This integer can be viewed as a quantized flux, which is discharged in a first-order phase transition that proceeds by the nucleation of charged branes. We provide a detailed case study of the scenario in which the tunneling event occurs during inflation.

Presenter: CHAKRABORTY, Priyesh

Session Classification: Parallel session - Theory I

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

We only have the axion

Tuesday 11 November 2025 14:00 (20 minutes)

Presenter: MELIA, Tom

Session Classification: Parallel session - Theory II

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

High-quality QCD Axion in the Standard Model—- Blue Bird Scenario of the Axion

Tuesday 11 November 2025 14:20 (20 minutes)

Presenter: YANAGIDA, Tsutomu

Session Classification: Parallel session - Theory II

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

All axion dark matter from supersymmetric models

Tuesday 11 November 2025 14:40 (20 minutes)

Supersymmetric models accompanied by certain anomaly-free discrete R-symmetries Z_n^R are attractive in that 1. the R-symmetry (which can arise from compactified string theory as a remnant of the broken 10-d Lorentz symmetry) forbids unwanted superpotential terms while allowing for the generation of an accidental, approximate global U(1)*{PQ} symmetry needed to solve the strong CP problem and 2. they provide a raison d'etre for an otherwise ad-hoc R-parity conservation. We augment the minimal supersymmetric Standard Model (MSSM) by two additional Z_n^R- and PQ-charged fields X and Y wherein SUSY breaking at an intermediate scale m*{hidden} leads to PQ breaking at a scale f_a\sim 10^{11} GeV leading to a SUSY DFSZ axion. The same SUSY breaking can trigger R-parity breaking via higher-dimensional operators leading to tiny R-violating couplings of order (f_a/m_P)^N and a WIMP quality problem. For Z_4^R and Z_8^R, we find only an N=1 suppression. Then the lightest SUSY particle (LSP) of the MSSM becomes unstable with a lifetime of order ~ 10^{-3}-10 seconds so the LSPs all decay away before the present epoch. That leaves a universe with all axion cold dark matter and no WIMPs in accord with recent LZ-2024 WIMP search results.

Presenter: ZHANG, Kairui

Session Classification: Parallel session - Theory II

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

Massive black hole binaries in ultralight dark matter solitons

Tuesday 11 November 2025 15:30 (20 minutes)

Ultralight dark matter (ULDM) is a dark matter candidate composed of light axion-like particles, and is a promising alternative to cold dark matter. A unique feature of ULDM is the formation of solitonic cores at the centre of collapsed halos, which may increase the drag experienced by black hole binaries orbiting within the soliton. We present high-resolution numerical simulations of the dynamics of SMBH binaries in the soliton of a massive halo, finding that higher ULDM particle masses can potentially alleviate the final parsec problem. We show that dynamical friction from ULDM can suppress gravitational wave power in the PTA band. Through fits to our simulations, we develop a semi-analytic model for orbital decay due to ULDM with the aim of constraining ULDM particle masses through PTA data.

Presenter: BOEY, Russell

Session Classification: Parallel session - Gravity II

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

Ultra-light dark matter and gravitational wave interferometers

Tuesday 11 November 2025 15:50 (20 minutes)

Ultra-light dark matter, a compelling candidate for the cosmological dark matter, is modelled as an oscillating classical field, existing as a superposition of nearly coherent waves of macroscopic wavelength. If ultra-light dark matter has spin 2 it would look like a (massive) continuous gravitational wave, and as such it would be detectable in gravitational wave interferometers. In this talk I review the theory behind spin 2 dark matter models and describe the analysis pipeline to detect it with LIGO/Virgo data. If time allows I will also discuss how levitated sensor detectors can test this type of dark matter.

Presenter: URBAN, Federico

Session Classification: Parallel session - Gravity II

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

Measurable Effects from Unresolvable Perturbations of Axion Dark Matter in the Critical Region of Gravitational Lenses

Tuesday 11 November 2025 16:10 (20 minutes)

Successful dark matter (DM) models have to predict the condensation of dark matter into haloes, reproducing the observed mass of galaxies and clusters in the Universe. Axionic DM, predicts an over-concentrated core 'soliton' residing within each of the haloes, which is a generic feature from models that effectively include interaction among the DM particles. This has been the major way to constrain axion parameter space from gravitational lens, and this aspect of axionic DM is not distinguishable with gravothermally collapsed self-interacting DM.

In this talk however, I would discuss utilising some exotic gravitational lenses to measure another prediction unique to axionic DM: the density modulations in the halo outskirt analogous to the excited states of hydrogen wavefunction. These density modulations are small and operate on a spatial scale below the resolution limit of the existing telescopes. Yet, they can be sustantially amplified in the 'near-critical region' of gravtational lens, thus resembling a cosmological 'transition-edge detector; Specifically, I would quantify the effect of axionic DM at the umbilic point of gravtational lens, revealing their unique imprint in terms of observable lens-magnified flux.
A recently executed proposal on JWST have observed such a special gravitational lens, the measurements of the fluxes distribution therein would soon give a stringent constraint, eventually narrowing down the axion parameter space."

Presenter: W.H. FUNG, Leo

Session Classification: Parallel session - Gravity II

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

Probing Axion-like Dark Matter via Time-Variable Polarization in Protoplanetary Disks

Tuesday 11 November 2025 15:30 (20 minutes)

Among the various dark matter candidates, axion-like dark matter—particularly in the ultralight regime around 10^−22 eV—has attracted significant attention in recent years, as it has been proposed as a potential solution to the small-scale structure problems in the standard cosmological model.
In this talk, we present a new observational constraint on ALP dark matter based on archival data from the Very Large Telescope (VLT). Specifically, we analyze time-series polarimetric data of HD 163296 and place limits on the coupling between ALP dark matter and photons. Furthermore, we show that if the uncertainty in the polarization angle can be reduced to 0.1° and high-cadence monitoring is achieved, the existing upper bounds can be significantly improved. This demonstrates the potential of time-domain polarimetry of nearby young stellar objects as a novel probe of ultralight dark matter.

Presenter: NARITA, Kanako

Session Classification: Parallel session - Cosmology II

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

Dynamical heating in Dwarf Spheroidal Galaxies in spin-s Ultra-light Dark Matter models

Tuesday 11 November 2025 15:50 (20 minutes)

Ultralight dark matter (ULDM), characterized by particles with masses log(m/eV) ~ -22 and de Broglie wavelengths on kiloparsec scales, behaves as a coherent quantum field at galactic scales. This wave-like nature drives time-dependent gravitational potential fluctuations that can dynamically heat stellar systems. In this talk, I will present the results of a numerical study of ULDM fluctuation-induced dynamical heating in dwarf spheroidal galaxies. We will analyze how this effect affects stellar velocity dispersion and the long-term stability of cold substructures. Our simulations explore a range of ULDM particle masses and initial stellar configurations, and we discuss the implications for current observational constraints. In particular, we investigate how the nature of the ULDM assuming spin-0 (scalar), spin-1 (vector), and spin-2 (tensor) configurations modifies the characteristics of the induced fluctuations and how these differences affect the heating rates of stellar systems.

Presenter: MUNIVE VILLA, Erick

Session Classification: Parallel session - Cosmology II

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

Revisiting Fuzzy Dark Matter Constraints: Accounting for Core–Halo Mass Relation Diversity

Tuesday 11 November 2025 16:10 (20 minutes)

The estimation of the fuzzy dark matter (FDM) particle mass from the Milky Way's dwarf satellite galaxies relies critically on the core–halo mass relation. Previous studies have generally assumed a one-to-one core–halo mass relation, despite growing evidence that this relation exhibits considerable intrinsic scatter. Neglecting this diversity could lead to artificially tight constraints and potentially false exclusions within the allowed FDM particle mass range inferred from stellar kinematics of the Milky Way's dwarf galaxies. Using eight Milky Way dwarf spheroidal galaxies, we re-estimate the allowed range of the FDM particle mass while incorporating the observed diversity in the core–halo mass relation. To further mitigate the degeneracy with the stellar velocity anisotropy—which remains unobservable—we adopt a flexible line-of-sight velocity distribution (LOSVD) by including the fourth-order stellar velocity moments, rather than assuming a conventional, fixed LOSVD form.

Presenter: WARDANA, Dafa

Session Classification: Parallel session - Cosmology II

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

Domain walls induced by domain walls in a two axion system

Wednesday 12 November 2025 14:00 (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 $\mathcal{O}(10^9)$ 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.

Presenter: LEE, Junseok

Session Classification: Parallel session - Gravity III

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

The Gravitational-Wave Symphony of Axion-like Particles

Wednesday 12 November 2025 14:20 (20 minutes)

The early Universe offers a unique window into fundamental physics far beyond the reach of terrestrial experiments. In this talk, I will discuss how ultra-light axionlike scalar fields—ubiquitous in extensions of the Standard Model—can leave observable imprints through stochastic gravitational waves (GWs) generated by parametric resonance in the post-inflationary era. Using lattice simulations across broad parameter ranges, we find that such dynamics can produce GW signals spanning from nanohertz to kilohertz frequencies, potentially explaining recent NANOGrav results while predicting signatures for ground-based detectors such as LIGO and Cosmic Explorer. Remarkably, the same mechanisms can also account for the genesis of dark matter or dark radiation, and even realize Affleck–Dine–type baryogenesis without invoking supersymmetry. The resulting picture connects cosmic evolution, particle physics, and gravitational-wave astronomy into a unified framework—where early-universe field dynamics may soon become experimentally testable across multiple frontiers.

Presenter: SAHA, Pankaj

Session Classification: Parallel session - Gravity III

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

Axion/ ALP scenario with high scale inflation

Wednesday 12 November 2025 14:00 (20 minutes)

Considering that next generation CMB experiments like LiteBIRD and CMBS4 will probe the gravitational wave from high scale inflation via the observation of B-mode. We study the DFSZ-like GUT scenario where QCD axion and ALP exist in the evolution of the universe. In the conventional DFSZ scenario, since the domain wall number is larger than one, axion DM with PQ scale lower than inflation scale is not allowed, while PQ scale larger than inflation scale suffers from isocurvature problem. In other words, high scale inflation is not in good terms with this scenario. In this study, we consider the case where the existence of ALP can decay the domain wall of axion. Therefore, there is no domain wall problem and DFSZ axion DM with high scale inflation can be allowed, which can be a target of the next generation measurements like CMB or further investigation like PTA.

Presenter: KONDO, Dan

Session Classification: Parallel session - CMB

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

Circularly polarized radiation from Axion-Photon conversion and CMB V-mode measurements

Wednesday 12 November 2025 14:20 (20 minutes)

In the presence of a background magnetic field, axions or axion-like particles (ALPs) can be resonantly converted to photons when their mass is nearly equal to the effective photon mass. In this paper, we propose a novel method to constrain the parameter space of ALPs by investigating the resulting imprints of axion-photon conversion in the cosmic microwave background (CMB) observations. We show that a helical magnetic field existing prior to the CMB epoch can generate an excess population of photons carrying net circular polarization due to the axion-photon conversion mechanism.

Consequently, current measurements of the angular power spectrum of circular polarization (V-mode) in the CMB can be used to constrain the parameter space of ALP mass and its coupling to photons.

In the optimistic scenario of a maximally helical magnetic field with strength $\sim \mathrm{nG}$, we find that CLASS observations at $40\,\mathrm{GHz}$ can probe the previously unconstrained regions of axion-photon coupling corresponding to ALP masses in the range $10^{-8} - 10^{-10}\,\mathrm{eV}$.

Presenter: KUSHWAHA, Ashu

Session Classification: Parallel session - CMB

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

Improved cosmological constraints on axion-lepton interactions

Wednesday 12 November 2025 14:40 (20 minutes)

We present improved cosmological constraints on lepton couplings to thermally produced axion-like particles (ALPs). These interactions can affect the expansion history of the early Universe and leave distinctive signatures on the Cosmic Microwave Background (CMB) and Baryon Acoustic Oscillations (BAO). We compute precise ALP energy spectra by numerically solving the full Boltzmann equation, accounting for non-equilibrium production effects. Using Planck 2018 and the latest DESI data, we obtain the tightest cosmological limits to date on lepton–ALP couplings.

Presenter: GOMUŁKA, Adam

Session Classification: Parallel session - CMB

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

Baryogenesis in the Axiverse

Thursday 13 November 2025 14:00 (20 minutes)

Axiogenesis links the baryon asymmetry and dark matter abundance through the dynamics of the QCD axion, but its minimal form overproduces dark matter and can exacerbate the QCD axion quality problem. In this talk, I'll show how these issues are naturally resolved in an axiverse framework, where the QCD axion arises from multiple interacting axions. This setup generates large axion velocities without spoiling the Strong CP solution and introduces new friction channels that reduce the relic abundance. The resulting theory makes imminently testable predictions for haloscopes, colliders, and the CMB.

Presenter: CYNCYNATES, David

Session Classification: Parallel session - Phenomenology II

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

Multimodal axion emissions from Abelian-Higgs cosmic strings

Thursday 13 November 2025 14:20 (20 minutes)

We show that axions can be produced from Abelian-Higgs cosmic strings due to the axion-gauge coupling. The strong magnetic field is confined in the string, and the electric field is induced around the moving string, allowing axion productions from the dynamics of cosmic strings. Our simulation on the string network shows multimodal axion emissions in the sense that axions are produced in both the low-energy and high-energy regimes. The former can contribute to the cold dark matter and the latter can be regarded as dark radiation. We found that the axion with sub-GeV mass can explain the current relic dark matter abundance and simultaneously predicts a sizable amount of dark radiation which can be probed by future observations.

Presenter: KITAJIMA, Naoya

Session Classification: Parallel session - Phenomenology II

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

Aspects of non-minimal couplings

Thursday 13 November 2025 14:00 (20 minutes)

Non-minimal couplings between vector fields, 3-forms, and scalars have emerged as intriguing candidates for dark matter and dark energy. At the same time, their theoretical study reveals unexpected features, including subtle issues with dynamics and consistency. In this talk, I will review recent developments in the study of non-minimal couplings, highlighting both their potential roles and some of the surprising properties that arise from their theoretical analysis.

Presenter: HELL, Anamaria

Session Classification: Parallel session - Theory II

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

Reheating after Axion Inflation and its implications

Thursday 13 November 2025 14:20 (20 minutes)

In modern cosmology, it is generally assumed that after inflation, the energy of the inflaton field is transferred to radiation through a process known as reheating.
Axion-like particles (ALPs) have recently attracted attention as potential inflaton candidates, since their shift symmetry naturally protects the flatness of the inflaton potential.

In this work, we study reheating in a model where the ALP couples to a non-Abelian gauge field via a Chern–Simons interaction. In this scenario, energy transfer proceeds resonantly, as familiar from preheating analyses, and is expected to be highly efficient. However, a significant challenge remains: even a small fraction of the inflaton may eventually come to dominate the energy density again.

In this talk, I will present how reheating is completed in this context and discuss its implications for observation."

Presenter: TSUJI, Tenta

Session Classification: Parallel session - Theory II

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

Examining Mass Enhancement in a High-Quality Composite Axion Model

Thursday 13 November 2025 14:40 (20 minutes)

The Peccei–Quinn (PQ) mechanism is a prominent solution to the strong CP problem. However, it faces the axion quality problem: higher-dimensional, Planck-suppressed operators which explicitly break PQ symmetry can reintroduce the effective QCD theta angle. In composite axion models, where strong dynamics at high energies dynamically break PQ symmetry, certain constructions address this quality problem. In some cases, hidden interactions distinct from QCD appear to contribute to the axion mass through instanton effects. I demonstrate that while these small instantons enhance the axion mass in a toy model, they do not contribute to the axion mass in an explicit model which addresses the quality problem.

Presenter: AOKI, Takafumi

Session Classification: Parallel session - Theory II

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

SPINN: Advancing Cosmological Simulations of Fuzzy Dark Matter with Physics Informed Neural Networks

Friday 14 November 2025 13:40 (20 minutes)

Physics-informed neural networks (PINNs) have emerged as a powerful tool for solving differential equations by integrating physical laws into the learning process. This work leverages PINNs to simulate gravitational collapse, a critical phenomenon in astrophysics and cosmology. We introduce the Schrödinger–Poisson (SP) informed neural network which solves the nonlinear SP equations to simulate the gravitational collapse of fuzzy dark matter (FDM) in both 1D and 3D settings. The results demonstrate accurate predictions of key metrics such as mass conservation, density profiles, and structure suppression, validating against known analytical or numerical benchmarks. This work highlights the potential of PINNs for efficient, possibly scalable modeling of FDM and other astrophysical systems, overcoming the challenges faced by traditional numerical solvers due to the nonlinearity of the involved equations and the necessity to resolve multiscale phenomena, especially resolving the fine wave features of FDM on cosmological scales. Next steps include full cosmological FDM simulations using physics informed generative modeling.

Presenter: KUMAR MISHRA, Ashutosh

Session Classification: Parallel session - Cosmology III

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

Cosmological Zoom-in simulations of Fuzzy Dark Matter dwarf halos in the field

Friday 14 November 2025 14:00 (20 minutes)

Ultra-light bosons are a promising candidate for the dark matter in the Universe. The quantum nature implies minimum halo mass scale below which structure formation is suppressed. The limited number of Self-consistent FDM simulations have reveal that non-linear collapse can yield soliton formation below the Jeans scale. In this talk, I will present a suite of FDM cosmological zoom-in simulations of dwarf mass halos in the field for various boson masses. I will show how these results can inform about the formation of the smallest scales and how that impacts the soliton core-halo mass relation.

Presenter: H. ROBLES, Victor

Session Classification: Parallel session - Cosmology III

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

Cosmology-informed constraints on the fuzzy dark matter mass from dwarf-spheroidal stellar kinematics

Friday 14 November 2025 14:20 (20 minutes)

Fuzzy dark matter (FDM) predicts a solitonic core within halos, in contrast to the cuspy inner profiles expected in the standard cold dark matter (CDM) model.
We investigate differences in the inner structure of dark matter halos through the stellar kinematics of dwarf spheroidal galaxies, which place constraints on the FDM particle mass.
We analyze the parameter space using a statistical framework with cosmology-informed priors derived from the Semi-Analytical SubHalo Inference ModelIng (SASHIMI), which restrict the outer NFW-like halo parameters to cosmologically motivated regions.
Guided by recent FDM simulations, we further assume a smooth connection between the inner soliton and outer NFW-like profiles, enabling an efficient constraint on the FDM mass. As shown in the previous study, Segue 1 provides most stringent constraint $m_{\rm FDM}$ $gtrsim 10^{-21}$ eV even when the cosmological priors are taken into account."

Presenter: HORIGOME, Shunichi

Session Classification: Parallel session - Cosmology III

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

Search for ALPs with mass near 2.3 eV via stimulated resonant photon scattering in a three-laser collision at a large crossing angle eV-mass

Friday 14 November 2025 13:40 (20 minutes)

Axion-like particles(ALPs) are attractive candidates that could explain reported excesses in the cosmic optical and infrared background. We aim to search for ALPs via stimulated resonant photon scattering by colliding three short-pulse lasers. By changing angle of incidence of the three beams, the center-of-mass-system collision energy can be varied and the eV mass range can be continuously searched for. In this talk, I will report initial point search performed with a large-crossing-angle setup.

Presenter: HASADA, Takumi

Session Classification: Parallel session - Experiments II

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

Precision Atomic Response Functions for Probing Dark Matter–Electron Scattering in Xenon and Germanium Detectors

Friday 14 November 2025 14:00 (20 minutes)

This work presents a comprehensive theoretical investigation of dark matter (DM)–electron interactions using atomic response functions (ARFs), with a focus on Germanium and Xenon—two widely employed detectors in direct detection experiments. Accurately modeling these interactions is essential for interpreting and guiding searches for light dark matter candidates, particularly in scenarios where DM particles interact with atomic electrons rather than nuclei.
Our goal is to develop a comprehensive set of ARFs at leading order (LO), derived using state-of-the-art atomic many-body methods. We show that the complex dynamics of DM-induced atomic ionization can be effectively described by four independent atomic response functions. These newly identified responses prove particularly significant in the context of light dark matter (LDM) scenarios, which we investigate using a model-independent effective field theory framework.
To achieve this, we employ the relativistic random-phase approximation (RRPA) and the relativistic frozen-core approximation (RFCA), enabling differential cross-section predictions with estimated accuracies of ~5% (RRPA) and ~20% (RFCA)[1,2, 3].
Using our computed ARFs, we set 90% confidence level exclusion limits on various DM-electron effective interaction operators by comparing with null results from current and ongoing experiments. In particular, our analysis is relevant to the CDEX and CDMSlite experiments, as well as xenon-based detectors such as XENONnT and other next-generation liquid xenon experiments. These detectors, with their increasing sensitivity to low-energy ionization signals, stand to benefit from the improved theoretical modeling provided by our atomic approach.
This study not only refines theoretical tools for interpreting DM-electron signals but also enhances the sensitivity of future searches. The results will be presented at an upcoming international conference.
[1] M. K. Pandey et al., Phys. Rev. D 102, 123025 (2020).
[2] C.-P. Liu et al., Phys. Rev. D 106, 063003 (2022).
[3] C.-P. Liu et al., arXiv:2501.04020."

Presenter: KUMAR PANDEY, Mukesh

Session Classification: Parallel session - Experiments II

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

Belle II

Friday 14 November 2025 14:20 (20 minutes)

The Belle and Belle II experiments have collected samples of e+e− collision data at and near the centre-of-mass energies near the Υ(nS) resonances. These data have constrained kinematics and low multiplicity, which allow searches for dark sector particles in the mass range from a few MeV to 10 GeV. Using samples of up to 711 fb−1 collected by Belle and 365 fb−1 collected by Belle II at the Υ(4S), we have performed searches of ALPs decaying to two photons and tau leptons; long-lived ALPs in bottom to strange quark transitions; and ALPs produced in bottom mesons decaying to two photons or invisible final states. We will present recent highlights from several ALPs and dark matter searches at Belle and Belle II.

Presenter: SHIMASAKI, Tomoyuki

Session Classification: Parallel session - Experiments II

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

Search for dark-matter axions beyond the quantum limit: the Cosmological Axion Sarov Haloscope (CASH) proposal and status

Friday 14 November 2025 14:40 (20 minutes)

Firmly established in astrophysical observations, dark matter evades direct detection in experiments. Axions and axion-like particles are among the leading dark-matter candidates, and numerous attempts to detect them in laboratories have been performed. Here, we propose to advance these efforts substantially, extending the sensitivity for dark-matter axions in the mass range 38-54 mu-eV down to the axion-photon couplings g_{agg} ~ 10^{-14}-10^{-15} GeV^{-1}, motivated by generic models of Quantum Chromodynamics axion. Single-photon detectors based on Josephson junctions operating at ultra-low temperatures are key elements of the experiment. The projected sensitivity will be reached in one year of data taking with magnetic field of 7 T, making Cosmological Axion Sarov Haloscope (CASH) the most sensitive haloscope in this mass range (based on arXiv:2506.18595 [hep-ph]). In addition, we discuss the sensitivity of proposed CASH experiment to relativistic axion flux. We report the current status of the first pathfinder run of CASH experiment.

Presenter: SATUNIN, Petr

Session Classification: Parallel session - Experiments II

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

Beyond Qubits: Multilevel Quantum Sensing for Axion Dark Matter

Thursday 13 November 2025 14:40 (20 minutes)

Quantum sensing with qubits has advanced fundamental physics searches, but higher dimensional systems offer untapped potential. We present a universal qutrit framework that yields a sequence-independent fourfold increase in quantum Fisher information and a twofold gain in sensitivity. In ultralight axion dark matter searches, spin-1 NV-center qutrits can enhance the axion-electron coupling reach by an order of magnitude beyond qubits. This principle applies broadly to multilevel quantum systems including superconducting, neutral atom and trapped-ion qutrits, establishing higher dimensional sensing as a powerful tool for probing new physics.

Presenter: MA, Xiaolin

Session Classification: Parallel session - Phenomenology II

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

Spinoptics in the presence of axion-like particles

In curved spacetime, the trajectory of a light ray is described by a geodesic under the geometric optics approximation.However, this approximation is valid only locally and is not justified int the all spacetime regions.If it breaks down, the polarization of light can affect its propagation.In this presentation, we consider light propagating through an axion field in spinoptics approximation.When the polarization is taken into account, the photon-axion coupling introduces an additional acceleration term into the ray equation.This acceleration causes the trajectories to differ depending on the helicity of the light in the presence of an axion field.

Presenter: TAKEUCHI, Tomoki

Session Classification: Parallel session - Gravity II

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

Spinoptics in the presence of axion-like particles

Wednesday 12 November 2025 14:40 (20 minutes)

In curved spacetime, the trajectory of a light ray is described by a geodesic under the geometric optics approximation.However, this approximation is valid only locally and is not justified int the all spacetime regions.If it breaks down, the polarization of light can affect its propagation.In this presentation, we consider light propagating through an axion field in spinoptics approximation.When the polarization is taken into account, the photon-axion coupling introduces an additional acceleration term into the ray equation.This acceleration causes the trajectories to differ depending on the helicity of the light in the presence of an axion field.

Presenter: TAKEUCHI, Tomoki

Session Classification: Parallel session - Gravity III

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

Constraints on extended axion structures from the lensing of fast radio bursts

Wednesday 12 November 2025 15:00 (20 minutes)

Axions are hypothetical pseudoscalar particles that have been regarded as promising dark matter (DM) candidates. On the other hand, extended compact objects such as axion stars, which are supported by gravity and axion self interactions, may have also been formed in the early Universe and comprise part of DM. In this work, we consider the lensing of electromagnetic signals from distant sources by axion stars, as a way to constrain the properties of axion stars and fundamental axion parameters. Accounting for the effect of the finite size of the axion star, we study the lensing effect induced by gravity, and by axion-photon interactions. The latter effect is frequency dependent, and is relevant in the low frequency band, which motivates the use of fast radio burst (FRB) signals as a probe. We calculate the predicted number of lensed FRB events by specifying the fundamental axion parameters, axion star radial profile, fraction of DM residing in axion stars, and imposing lensing criteria based on the flux ratio and time delay between the brightest images from lensing. Assuming an optimistic case of 10^4 observed FRB events, and a timing resolution of $1\,\mu$s, the lack of observed FRB lensing events in CHIME allows us to probe axion stars with mass $gtrsim10^{-2}M_\odot$, corresponding to axion masses
$lesssim10^{-10}\,\mathrm{eV}$ and for negligible axion-photon couplings. Even lighter axion stars up to $\sim 10^{-3}M_\odot$ can be probed, assuming axion-photon couplings of at least $10^{-6}\,\mathrm{GeV}^{-1}$. Our results indicate that while FRB lensing by axion stars lead to sensitivities that are competitive with conventional microlensing searches operating in the optical band, it remains a challenge to probe axion-photon induced lensing effects.

Presenter: CHOU, Kuan-Yen

Session Classification: Parallel session - Gravity III