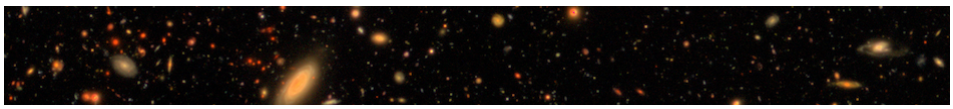
Workshop on Very Light Dark Matter 2021



Report of Contributions

https://indico.ipmu.jp/e/392

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

ABRACADABRA-10cm: First Search for < 1micro-eV Axions

Monday, 27 September 2021 10:10 (40 minutes)

The axion is an intriguing dark matter candidate that has returned too prominence due to advances in quantum sensors and cryogenic infrastructure. The < 1micro-eV mass range for axions is particularly intriguing due its connection to the GUT-scale. In this talk, I will introduce axion physics in this mass range and present the latest results from ABRACADABRA-10cm's second physics run.

Presenter: WINSLOW, Lindley

Session Classification: Monday AM

Track Classification: Invited

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

Axion-like particle dark matter and gravitational waves from topological defects

Monday, 27 September 2021 10:50 (25 minutes)

Axion-like particles (ALPs) are a compelling candidate for dark matter (DM). Their production is associated with the formation of a string-wall network. This system must annihilate, producing gravitational waves and non-relativistic ALPs. In my talk I will show that these gravitational waves, if produced at temperatures below 100 eV, could be detected by future cosmological probes for ALPs with mass from 10^{-16} to 10^{6} eV, opening a window on ALP DM with arbitrary small couplings to the Standard Model.

Presenter: VITAGLIANO, Edoardo

Session Classification: Monday AM

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

Dynamical friction from scalar dark matter

Monday, 27 September 2021 11:25 (25 minutes)

Light bosonic scalars (e.g. axions) may form clouds around black holes via superradiant instabilities, or via accretion if they form some component of the dark matter. It has been suggested that their presence may lead to a distinctive dephasing of the gravitational wave signal when a small compact object spirals into a larger black hole. Motivated by this, we study numerically the dynamical friction force on a black hole moving at relativistic velocities in a background scalar field with an asymptotically homogeneous energy density.

Presenter: HELFER, Thomas

Session Classification: Monday AM

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

Hunting Axions Using Astrophysical Observation and Quantum Metrology

Monday, 27 September 2021 11:50 (25 minutes)

Ultralight bosons behave like coherent waves when the occupation number is large enough. If they are coupled to the Standard Model sector of the particle physics, such an oscillating background can induce a tiny signal. Near a fast rotating black hole, axion within one order of the mass window can accumulate through superradiance, with a large density saturating the non-linear self-interaction. If linearly polarized radiation is emitted near the black hole, axion can contribute to birefringence effect that shifts the position angle periodically, making the polarimetric measurements of the Event Horizon Telescope a powerful way to look for ultra-light axions. On the other hand, quantum metrology can play huge roles in the measurements of fundamental physics. Among these, resonant detection of axion dark matter based on electromagnetic coupling is a popular direction attracting many ongoing experiments and proposals such as microwave cavity, LC circuit and superconducting radio-frequency cavity. A quantum network of resonators can strongly enhance the signal power and boost the search. A network of spin dependent sensors with long baseline can identity the microscopic nature of dark matter or other cosmological background and increase the spatial resolution for transient source like axion or dark photon wave as well.

Presenter: CHEN, Yifan

Session Classification: Monday AM

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

Squeezed quantum states of axions

Monday, 27 September 2021 14:00 (40 minutes)

In this talk, I will discuss the production of axions from the vacuum caused by the expansion of the Universe. I will show the axions evolve as a squeezed state during inflation and become a highly entangled state. Such a quantum squeezed state of axions remains after horizon re-entry. I also discuss the observability of the quantum coherence of axions.

Presenter: KANNO, Sugumi

Session Classification: Monday PM

Track Classification: Invited

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

The DAMNED Experiment : Dark matter Scalar field search with Optical Cavity and an Unequal-Delay Interferometer

Monday, 27 September 2021 14:40 (25 minutes)

The DAMNED experiment is a new type of experiment that compares the frequency of a clock to itself in the past, by "storing" photons in a fibre delay line.

In ultra-light oscillating dark matter (DM) models, the coupling of DM to the standard model fields yields an oscillation of fundamental constants, which in turn leads to oscillations of the cavity and fibre lengths and of the fibre refractive index. Additionally, the sensitivity is significantly amplified around the mechanical resonance frequencies of the cavity. We present experimental result of such an experiment and report no evidence of DM for frequencies in the [10, 200] kHz region [Savalle et al., PRL 126, 051301 (2021)].

In order to take into account the stochastic property of the DM scalar field, we have developed and used a Bayesian analysis method whose versatility allows it to be applied to similar experiments.

Taking advantage of the experiment enhanced sensitivity and the tailored data analysis, we are able to improve constraints on the involved coupling constants by one order of magnitude in a standard galactic DM model, at the mass corresponding to the resonant frequency of our cavity.

Furthermore, in the model of relaxion DM, we improve on existing constraints over the whole DM mass range by about one order of magnitude, and up to six orders of magnitude at resonance.

Presenter: SAVALLE, Etienne

Session Classification: Monday PM

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

Search for ultra-light dark matter with the Shuket experiment

Monday, 27 September 2021 15:05 (25 minutes)

P. Brun, L. Chevalier, C. Flouzat, A. Hees, P. Polovodov, E. Savalle, P. Wolf

The Shuket experiment aims at detecting light scalar dark matter in the form of hidden photons. Shuket stands for SearcH for U(1) darK matter with an Electromagnetic Telescope, it is designed as a metallic spherical cap with a radiometer at its center. We present the results of a re-analysis of a dataset presented in [P. Brun et al, PRL 122, 201801, 2019]. A new method is used, which takes into account the stochastic character of the signal and a realistic dark matter velocity distribution. The new analysis leads to improved constraints on scalar dark matter in a 7.5 eV mass range around 24.6 eV, corresponding to an oscillation frequency centered on 5.9 GHz. We discuss also near and medium term plans for the experiment, including new runs for hidden photons and upgrades for axion detection.

Presenter: BRUN, Pierre

Session Classification: Monday PM

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

Exploring Dark Matter ALPs and FIPs

Monday, 27 September 2021 15:40 (40 minutes)

In this talk we will look at axion-like particles, and other very feebly interacting (light) dark matter candidates. In particular we will look at some more unusual features and models.

Presenter: JAECKEL, Joerg

Session Classification: Monday PM

Track Classification: Invited

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

Searching for axion-like particles under strong gravitational lenses

Monday, 27 September 2021 16:20 (40 minutes)

We establish strong gravitational lens systems as robust probes of axion-like particles (ALPs) – a candidate for dark matter. A tiny interaction of photons with ALPs induces birefringence. Multiple images of gravitationally lensed polarised objects allow differential birefringence measurement, alleviating systematics and astrophysical dependencies. We apply this novel method to the lens system CLASS B1152+199 and constrain ALP-photon coupling for ultra-light ALPs. We also discuss the forecast of future observations.

Presenter: URAKAWA, Yuko

Session Classification: Monday PM

Track Classification: Invited

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

Searching Dark Matter with Galileo satellites

Monday, 27 September 2021 17:00 (15 minutes)

The search of transient space variation of fundamental constant, like the fine structure constant or the proton-to-photon mass ratio in the neighborhood of the Earth, is the interest of last decades. In this context, atomic clocks can present an astonishing tool for study fundamental physics in terms of detection of a possible frequency shift, which is a result of GPS network interaction with Dark Matter objects.

In this work, we consider a system of Galileo satellites with a passive H-maser on boards to test transient violation using propagation of electromagnetic signal. Here, we present data analysis based on 90-days measurement campaign carried during January – March 2021. The novelty of this work is the combination of measurements (clocks and orbit products, SLR measurements) for the search for DM transients, with a special care to the systematic effects.

Presenter: SHEREMET, Alexandra

Session Classification: Monday PM

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

Searching for Axion Echos from Supernova Remnants

Tuesday, 28 September 2021 14:00 (15 minutes)

In this talk, I will discuss possible constraints on the axion-photon coupling arising from supernova remnants. I will assume axion to be dark matter and focus on the echo signal from its stimulated decay process, which is caused by photons in the radio band emitted from supernova remnants. I will show that this could put competitive bounds in the mass range of 10^{-6} eV to 10^{-4} eV.

Presenter: SUN, Chen

Session Classification: Tuesday PM

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

Pre-supernova Axion-like Particles and Their Detectability

Tuesday, 28 September 2021 14:15 (15 minutes)

Ultralight axion-like particles (ALPs) are a candidate of dark matter particles. We calculate the production of ALPs in a nearby supernova progenitor. Once produced, ALPs escape from the star and a part of them is converted into photons during propagation in the Galactic magnetic field. We report that the MeV photon flux that reaches Earth may be detectable by gamma-ray telescopes for ALPs lighter than ~1 neV when Betelgeuse undergoes oxygen and silicon burning. (Non-)detection of gamma-rays from a supernova progenitor with next-generation gamma-ray telescopes just after pre-supernova neutrino alerts would lead to an independent constraint on ALP parameters as stringent as an SN 1987A limit.

Presenter: MORI, Kanji

Session Classification: Tuesday PM

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

Axion in antiferromagnetic insulators

Tuesday, 28 September 2021 10:00 (40 minutes)

Presenter: ISHIWATA, Koji

Session Classification: Tuesday AM

Track Classification: Invited

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

Axion dark matter search with magnons

Tuesday, 28 September 2021 10:40 (40 minutes)

The axion provides a solution for the strong CP problem and is one of the leading candidates for dark matter. In this talk, we propose an axion detection scheme based on quantum nondemolition detection of magnons, i.e., quanta of collective spin excitations in a ferromagnetic crystal. Furthermore, we give an upper limit on the coupling constant between an axion and an electron for a certain mass of the axion dark matter.

Presenter: ITO, Asuka

Session Classification: Tuesday AM

Track Classification: Invited

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

Axion clouds may survive the perturbative tidal interaction over the early inspiral phase of black hole binaries

Tuesday, 28 September 2021 11:30 (15 minutes)

Axion forms a cloud around a rotating black hole (BH) by superradiant instability. On the other hand, considering the cloud associated with a BH in a binary system, tidal interaction depletes the cloud in some cases during the inspiral phase. To clarify the condition that clouds avoid disappearing, we made the exhaustive study of cloud depletion numerically in a wide parameter range for equal mass binaries.

Presenter: TAKAHASHI, Takuya

Session Classification: Tuesday AM

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

An analytic model for the sub-galactic matter power spectrum in fuzzy dark matter halos

Tuesday, 28 September 2021 11:45 (15 minutes)

Fuzzy dark matter (FDM) is one of the promising alternative dark matter candidates to cold dark matter. The quantum clumps, which is a unique structure of FDM, can be seen in halos in cosmological FDM simulations. In this talk, we first provide our analytic model of the sub-galactic matter power spectrum originating from quantum clumps in FDM halos. Then we show a result of a comparison between the sub-galactic matter power spectrum projected along the line of sight around the Einstein radius with our model and that measured in the strong lens system SDSS J0252+0039. While we find that the current observation provides no useful constraint on the FDM mass, we show that future deep, high spatial resolution observations of strong lens systems can tightly constrain FDM with the mass around10^{-22}eV.

Presenter: KAWAI, Hiroki

Session Classification: Tuesday AM

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

Supernova constraint on the light dark particles

Tuesday, 28 September 2021 14:30 (15 minutes)

The well-established supernova bound on sub-GeV particles in the dark sectors has been applied to various dark sector candidates, including axion, dark photon, sterile neutrinos, etc. Recently, we found that on one hand one can extend the supernova bound by considering the decay of dark particles in the stellar envelope that can add energy to the explosion of the supernova [1]. On the other hand, if light dark sector particles have sizable interactions between themselves, this self-interaction can result in self-trapping of dark sector particles to evade the supernova bound [2].

[1] A. Sung, H. Tu, M.-R. Wu, Phys.Rev.D 99 (2019) 12, 121305.

[2] A. Sung, G. Guo, M.-R. Wu, Phys.Rev.D 103 (2021) 10, 103005.

Presenter: WU, Meng-Ru

Session Classification: Tuesday PM

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

The imprint of ultralight vector dark matter on gravitational-wave propagation

Tuesday, 28 September 2021 15:40 (25 minutes)

In this talk we analyse the effect of ultralight vector dark matter on gravitational-wave propagation. We find that the presence of the field produces an anisotropic suppression of the gravitational-wave amplitude, which depends on the mass and the abundance of the field. The effect is sizable for primordial gravitational waves, and could be detected with forthcoming cosmic microwave background B-mode polarization detectors for small masses ($m \sim 10^{-26}$ eV) and sufficiently large abundances.

Presenter: MIRAVET, Alfredo Delgado

Session Classification: Tuesday PM

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

Dark Photon Limits: A Cookbook

Tuesday, 28 September 2021 15:15 (25 minutes)

The dark photon is a massive hypothetical particle that interacts with the Standard Model by kinetically mixing with the visible photon. Due to the similarity with the electromagnetic signals generated by axions, many putative bounds on dark photon signals are simply reinterpretations of historical bounds set by axion haloscopes. However, the dark photon has a property that the axion does not: an intrinsic polarization. Due to the rotation of the Earth, accurately incorporating this polarization into dark photon analyses is nontrivial, and highly experiment-dependent. Several well-known searches for axions employ techniques for testing signals that preclude their ability to set exclusion limits on dark photons, and hence should not be reinterpreted as such. Most experiments do not have a straight forward reinterpritation for polarized dark photons. On the other hand, we find that if one does account for the dark photon's polarization, and the rotation of the Earth, an experiment's discovery reach can be improved by an order of magnitude. Here, we detail the strategies that would need to be taken to properly optimise a dark photon search. These include a judiciously choosing the orientation of the experiment, as well as strategically timing any repeated measurements and splitting measurements into multiple parts. Such strategies have significant impact on limits without additional time or cost.

Presenter: MILLAR, Alexander

Session Classification: Tuesday PM

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

Constraints on dark photon dark matter using data from LIGO's and Virgo's third observing run

Tuesday, 28 September 2021 16:05 (40 minutes)

We present a search for dark photon dark matter that could couple to gravitational-wave interferometers using data from Advanced LIGO and Virgo's third observing run. To perform this analysis, we use two methods, one based on cross-correlation of the strain channels in the two nearly alignedLIGO detectors, and one that looks for excess power in the strain channels of the LIGO and Virgo detectors. The excess power method optimizes the Fourier Transform coherence time as a function of frequency, to account for the expected signal width due to Doppler modulations. We do not find any evidence of dark photon dark matter with a mass between mA ~ 1e−14 to 1e-11eV/c2, which corresponds to frequencies between 10-2000 Hz, and therefore provide upper limits on the square of the minimum coupling of dark photons to baryons, i.e.U(1)B dark matter. For the cross-correlation method, the best median constraint on the squared coupling is~1.31e−47 at mA~4.2e−13 eV/c2; for the other analysis, the best constraint is~2.4e−47

at mA~5.7e−13 eV/c2. These limits improve upon those obtained in direct dark matter detection experiments by a factor of~100 for mA~[2−4]e−13 eV/c2, and are, in absolute terms, the most stringent constraints so far in a large mass range mA~2e−13 to 8e−12 eV/c2

Presenter: MILLER, Andrew

Session Classification: Tuesday PM

Track Classification: Invited

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

Direct limits for scalar field dark matter from a gravitational-wave detector

Tuesday, 28 September 2021 16:45 (25 minutes)

We report on the first direct search for scalar field dark matter utilising a gravitational-wave detector. Scalar field dark matter is predicted to cause oscillations of fundamental constants, which in turn would drive oscillations of the size and index of refraction of the beamsplitter in an interferometer. This would thus produce an oscillatory signal in a gravitational-wave detector at a frequency set by the mass of the dark matter particle. We set new upper limits for the coupling constants of scalar field dark matter as a function of its mass, by excluding the presence of possible dark matter signals in data from the GEO600 interferometer. The new constraints improve upon bounds from previous direct searches by more than six orders of magnitude, and are in some cases more stringent than limits obtained in tests of the equivalence principle by up to four orders of magnitude. Our work demonstrates that scalar field dark matter can be probed or constrained with direct searches using gravitational-wave detectors, and highlights the potential of quantum-enhanced interferometry for dark matter detection.

Presenter: VERMEULEN, Sander

Session Classification: Tuesday PM

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

Searching for ultralight bosons with supermassive black hole ringdown

Tuesday, 28 September 2021 14:45 (15 minutes)

One class of competitive candidates for dark matter are ultralight bosons.

If they exist, these bosons may form long-lived bosonic clouds surrounding rotating black holes via superradiant instabilities, acting as sources of gravity and affecting the propagation of gravitational waves around the host black hole.

During extreme-mass-ratio inspirals, the bosonic clouds will survive the inspiral phase and can affect the quasinormal-mode frequencies of the perturbed black-hole-bosonic-cloud system.

In this work, we compute the shifts of gravitational quasinormal-mode frequencies of a rotating black hole due to the presence of a surrounding bosonic cloud.

We then perform a mock analysis on simulated LISA observational data containing injected ringdown signals from supermassive black holes with and without a bosonic cloud.

We find that with less than an hour of observational data of the ringdown phase of nearby supermassive black holes such as Sagittarius A* and M32, we can rule out or confirm the existence of cloud-forming ultralight bosons of mass $\sim 10^{-17}\mathrm{eV}$.

(The talk is based on arXiv:2107.05492, which has just been accepted by Physical Review D)

Presenter: ADRIAN, KA-WAI CHUNG

Session Classification: Tuesday PM

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

The Ubiquitous Axion in Quantum Gravity

Wednesday, 29 September 2021 10:00 (40 minutes)

Axion-like fields appear in many string theory constructions. I will discuss a proposed explanation for why they are so ubiquitous: they play a crucial role in eliminating would-be global symmetries from the theory. This perspective also gives a new perspective on axion interactions with magnetic monopoles. I will explain how magnetic monopole loops give rise to an axion potential.

Presenter: REECE, Matthew

Session Classification: Wednesday AM

Track Classification: Invited

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

Constraints to SFDM from Internal Structure and Orbital Parameters of Milky Way Satellites

Wednesday, 29 September 2021 10:40 (25 minutes)

Recent measurements of both internal density structure and global orbital properties of Milky Way dwarf galaxies hold the promise of tightly constraining or ruling out the allowed parameter space of ultra-light (scalar field) dark matter (SFDM) models. Recent SFDM simulations evolving the Schroedinger-Poisson system have led to new insights into the structure of isolated scalar field dark matter halos, revealing a compact and dense central soliton surrounded by quantum interference. However, the computational demands of current simulations render them unsuitable to capture the evolution of satellite halos, which then requires semi-analytical models. In this talk, I will present for the first time a new formalism that establishes the survivability of a soliton subhalo accreted into the Milky Way virial radius and show the implied tight constraints on the dark matter particle mass when comparing with the MW satellite dynamical and orbital constranints from Gaia. My results reveal a small region for the particle mass where the SFDM model is consistent with astrophysical data.

Presenter: ROBLES, Victor

Session Classification: Wednesday AM

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

On the Random Motion of Nuclear Objects in a Fuzzy Dark Matter Halo

Wednesday, 29 September 2021 11:15 (25 minutes)

Fuzzy Dark Matter (FDM), consisting of ultralight bosons (m_b ~ 10^{-22} eV), is an intriguing alternative to Cold Dark Matter. Numerical simulations that solve the Schrodinger-Poisson (SP) equation show that FDM halos consist of a central solitonic core, which is the ground state of the SP equation, surrounded by an envelope of interfering excited states. These excited states also interfere with the soliton, causing it to oscillate and execute a confined random walk with respect to the halo center of mass. Using high-resolution numerical simulations of a 6.6 x 10^{9} M_sun FDM halo with m_b = 8 x 10^{-23} eV in isolation, we demonstrate that the wobbling, oscillating soliton gravitationally perturbs nuclear objects, such as supermassive black holes or dense star clusters, causing them to diffuse outwards. In particular, we show that, on average, objects with mass < 0.3 % of the soliton mass (M_sol) are expelled from the soliton in ~ 3 Gyr, after which they continue their outward diffusion due to gravitational interactions with the soliton and the halo granules. More massive objects (> 1 % M_sol), while executing a random walk, remain largely confined to the soliton due to dynamical friction. We briefly discuss how the observed displacements of star clusters and active galactic nuclei from the centers of their host galaxies can be used to constrain FDM.

Presenter: CHOWDHURY, Dhruba Dutta

Session Classification: Wednesday AM

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

Bounding long-range force from dark matters with binary pulsars

Wednesday, 29 September 2021 11:40 (15 minutes)

The orbital dynamics of binary pulsars is influenced by a possible long-range fifth-force from the Galactic dark matter distribution. It is constrained with current binary pulsar experiments, and will be bound further with binary pulsar systems near the Galactic Center. [Shao, Wex, Kramer, PRL 120 (2018) 241104]

Presenter: SHAO, Lijing

Session Classification: Wednesday AM

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

On the quantum origin of a small positive cosmological constant

Wednesday, 29 September 2021 17:05 (15 minutes)

We show that Dark Matter consisting of ultralight bosons in a Bose-Einstein condensate induces, via its quantum potential, a small positive cosmological constant which is close to the observed value. This explains why the densities of Dark Matter and Dark Energy are approximately equal.

Presenter: DAS, Saurya

Session Classification: Wednesday PM

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

Revisiting the core-halo structure of Fuzzy Dark Matter Halo

Wednesday, 29 September 2021 14:00 (25 minutes)

In simulations of Fuzzy Dark Matter (FDM) model, we always found gravitationally collapsed object composed of a solitonic core locating within a virialized halo. Although a measured relation between the core and halo mass, from simulation, is often adopted to make observational constraints on the particle mass, there is still a disagreement on the relation between different groups. To fully understand the relation, we have performed idealized soliton mergers and cosmological FDM simulation by solving the time-dependent Schrodinger-Poisson equation. We obtained large samples of core-halo structure which allows us to directly compare with the core-halo relation of previous works. We provided a simple empirical equation for the core-halo mass relation and, more importantly, found a diversity in the core-halo structure. The diversity implies that any observational constraint on the particle mass that adopted the core-halo mass relation will suffer from an additional 50% error. We suggest that the origin of the diversity is related to the environmental effect, such as tidal stripping, which requires simulations with more efficient numerical scheme to confirm. We will also shortly discuss other radius-halo mass relation which may pose a challenge to the FDM model, but motivate future FDM simulations to include baryonic physics.

Presenter: HEI YIN JOWETT CHAN

Session Classification: Wednesday PM

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

DMRadio: Searching for Axion Dark Matter Below 1 ueV

Wednesday, 29 September 2021 14:25 (25 minutes)

The particle nature of Dark Matter (DM) is one of the most important open questions in particle physics today. Axions, and axion like particles (ALPs), more generally, have emerged as one of the leading candidates to to explain the DM abundance of the universe. Experimental searches for axion DM (aDM) have traditionally searched in a narrow mass band between 1~100 ueV using microwave cavity detectors. However, recent work has demonstrated a powerful new approach to search for aDM with mass <1ueV using a lumped element detector. DMRadio is a multiphase program to search for aDM with mass below 1 ueV. The first stage, DMRadio-50L is a toroidal detector with a 0.1-1 T magnetic field that will be able to probe aDM over the range 20 peV< m_a <20 neV down to $g_{a\gamma\gamma} \sim 5\times10^{-15}$ GeV^{-1}. The second stage, DMRadio-m3, will have a ~4 T field and will be sensitive to aDM in the QCD axion band from 20 neV<m_a<0.8ueV. In this talk, I will give an overview of the DMRadio program, design considerations, and challenges.

Presenter: OUELLET, Jonathan

Session Classification: Wednesday PM

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

Cosmic birefringence and its implications for axion phenomenology

Wednesday, 29 September 2021 14:50 (40 minutes)

A recent measurement of the non-zero isotropic birefringence angle with a 2.4 sigma level in Planck 2018 polarization data opens a tantalizing window for testing the parity-violating extension of the Standard Model. In this talk, I will explain the measurement of cosmic birefringence and discuss its implications for dark matter and dark energy models in the context of axion physics.

Presenter: GASPAROTTO, Silvia

Session Classification: Wednesday PM

Track Classification: Invited

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

A Catalogue of Hadronic Axion Models

I will report on or recent results on creating catalogues of hadronic, aka KSVZ, axion models. In particular, when phenomenological selection criteria are taken into account, we find a finite number of possible anomaly ratios E/N, and hence a finite number of hadronic axion models at any given mass. The number of different E/N values is between 12 and 820, depending on the amount of freedom allowed for charge assignments. I will comment on the ensuing distributions of the axion-photon coupling and the consequences for the detection of hadronic axion models. [arXiv:2107.12378]

Presenter: HOOF, Sebastian

Session Classification: Wednesday PM

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

Axion Dark Matter in the Time of Primordial Black Holes

Wednesday, 29 September 2021 16:05 (15 minutes)

In this talk, we present the phenomenology of QCD axion dark matter in a nonstandard cosmological era triggered by PBHs that fully evaporate before the onset of BBN. We show that PBHs have a strong impact on the dark matter produced via the misalignment mechanism. First, the oscillation temperature of axions reduces if there is a PBH dominated era, and second, PBH evaporation injects entropy, diluting the axion relic abundance originally produced. The axion window is therefore enlarged, reaching masses as light as $\sim 10^{-8}$ eV and decay constants as large as $f_a \sim 10^{14}$ GeV without fine tuning the misalignment angle.

Presenter: XU, Yong

Session Classification: Wednesday PM

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

Search for DM self-annihilation to neutrino production in KamLAND

Wednesday, 29 September 2021 16:35 (15 minutes)

KamLAND is an ultra-low BG detector with 1000 tons of liquid scintillator.

Taking advantage of this characteristic, we have made great achievements in the neutrino detection, and it can be fully utilized for dark matter search.

In this talk, the result of searching MeV-scale DM self-annihilation to neutrino production in KamLAND. No significant excess was found over the background model, so we set the most stringent upper limit on the DM self-annihilation cross section bellow about 15 MeV.

In addition, we show the DM search we are doing in KamLAND.

Presenter: HATA, Kazumi

Session Classification: Wednesday PM

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

PyUltraLight 2: Simulating Interactions Between Ultra-Light Dark Matter and Massive Particles

Wednesday, 29 September 2021 16:20 (15 minutes)

I will discuss simulations a massive objects interacting with ULDM, using an extension of the PyUltraLight code. Simulations of a point mass moving in a uniform background and a SMBH moving within a ULDM soliton broadly confirm simple estimates of dynamical friction timescales. However, in addition to generating complex inhomogeneities, SMHB-ULDM interactions excite coherent “breathing modes’’ in the soliton. The resulting stochastic dynamics increases the complexity of SMBH-ULDM interactions and is likely to have implications for SMBH merger rates in a ULDM-dominated universe.

Presenter: WANG, Yourong

Session Classification: Wednesday PM

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

Axion dark matter search with gravitational wave detectors: ADAM-GD

Monday, 27 September 2021 12:15 (15 minutes)

Axion is a promising candidate for ultralight dark matter which may cause a polarization rotation of laser light. Recently, a new scheme of probing the axion dark matter by optical linear cavities used in the arms of gravitational wave detectors has been proposed. This scheme is called ADAM-GD. If this scheme is applied, the sensitivity to the axion-photon coupling of the ground-based gravitational wave detector, such as KAGRA, with 1-year observation is estimated to be better than that achieved by the CERN Axion Solar Telescope below the axion mass of 10^(-10) eV.

Presenter: NAGANO, Koji

Session Classification: Monday AM

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

DANCE: Searching for Axion-like particle dark matter with optical bow-tie ring cavity

Tuesday, 28 September 2021 12:00 (15 minutes)

DANCE stands for Dark matter Axion search with riNg Cavity Experiment, and aims to detect the axion-like particle (ALP) dark matter by using laser interferometric techniques. ALPs interact with photons slightly and cause the rotational oscillation of linearly polarized light. The bow-tie ring cavity of DANCE can enhance the amplitude of the rotational oscillation by extending the effective optical path length and the interaction time. The detection sensitivity of DANCE is several orders of magnitude higher compared to the upper limit on the axion-photon coupling constant in the mass range below 10^{-10} eV. We report on the current status of the prototype experiment: DANCE Act-1. The sensitivity of the current DANCE Act-1 is degraded by around 3 orders of magnitude due to the resonant frequency difference between s- and p- polarizations. We report on the plans to realize the simultaneous resonance by using an auxiliary cavity or a tunable laser. We also discuss the analysis of the obtained 10-hour data to veto the candidate peaks of the ALP dark matter.

Presenter: FUJIMOTO, Hiroki

Session Classification: Tuesday AM

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

Ultralight Vector Dark Matter search with KAGRA

Tuesday, 28 September 2021 17:10 (15 minutes)

Gravitational Wave interferometer can be used for measuring the small displacement of the test masses due to the Ultralight vector dark matter (DM). However, the effects of the vector DM to the different mirrors are mostly common and the sensitivity is largely reduced, if they are made of the same material. Here, we would like to emphasize that KAGRA employs sapphire test masses and fused silica auxiliary mirrors. Such a difference in materials drastically enhances the sensitivity of the auxiliary length channels and enables us to probe the unexplored parameter region of, for example, the U(1)B−L gauge boson. In this talk, we present the current status of the pipeline for the vector DM search with KAGRA and discuss the prospects of our analysis with the data from KAGRA's first observing run in 2020.

Presenter: KUME, Jun'ya

Session Classification: Tuesday PM

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

Cosmic Birefringence Triggered by Dark Matter Domination

Wednesday, 29 September 2021 16:50 (15 minutes)

Recently, the Planck 2018 polarization data of cosmic microwave background (CMB) radiation suggested the non-zero rotation angle of CMB polarization plane, which is called cosmic birefringence. Cosmic birefringence is predicted if an axion-like particle (ALP) moves after the recombination. We show that this naturally happens if the ALP is coupled to the dark matter density because it then acquires a large effective mass after the matter-radiation equality. Our scenario applies to a broad range of the ALP mass, even smaller than the present Hubble constant. We give a simple model to realize this scenario where dark matter is made of hidden monopoles which give the ALP such a large effective mass through the Witten effect. The mechanism works if the ALP decay constant is of order the GUT scale without a fine-tuning of the initial misalignment angle.

Presenter: NAKAGAWA, Shota

Session Classification: Wednesday PM

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

Axion dark matter and inflation scale

Wednesday, 29 September 2021 11:55 (15 minutes)

I show that the upper bound of the classical QCD axion window can be significantly relaxed with (not too) low-scale inflation. If the Gibbons-Hawking temperature during inflation is lower than the QCD scale and the inflation lasts long enough, the initial QCD axion misalignment angle follows the Bunch-Davies distribution. The distribution is peaked at the strong CP conserving minimum if there is no other light degree of freedom contributing to the strong CP phase. As a result, the axion can be the dark matter even for the mass much lighter than μeV. I also discuss some applications of the mechanism.

Presenter: YIN, Wen

Session Classification: Wednesday AM

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

Asteroid Tracking Array and Space Quantum Technology for Fundamental Physics

Wednesday, 29 September 2021 12:10 (15 minutes)

We study for the first time the possibility of probing long-range fifth forces utilizing asteroid astrometric data, via the fifth force-induced orbital precession. We examine nine Near-Earth Object (NEO) asteroids whose orbital trajectories are accurately determined via optical and radar astrometry. Focusing on a Yukawa-type potential mediated by a new gauge field (dark photon) or a baryon-coupled scalar, we estimate the sensitivity reach for the fifth-force coupling strength and mediator mass in the mass range $m \simeq 10^{-21} - 10^{-15}\,\mathrm{eV}$. Our estimated sensitivity is comparable to leading limits from torsion balance experiments, potentially exceeding these in a specific mass range. The fifth forced-induced precession increases with the orbital semi-major axis in the small m limit, motivating the study of objects further away from the Sun. We discuss future exciting prospects for extending our study to more than a million asteroids (including NEOs, main-belt asteroids, Hildas, and Jupiter Trojans), as well as trans-Neptunian objects and exoplanets. Our work can also be applied to the studies of dark matter and gravitational waves. The new development of NASA/NIST proposals of Quantum technologies in Space could bring drastic improvements to our studies, which I will discuss briefly near the end of the talk. This talk is mainly based on https://arxiv.org/abs/2107.04038.

Presenter: TSAI, Yu-Dai

Session Classification: Wednesday AM