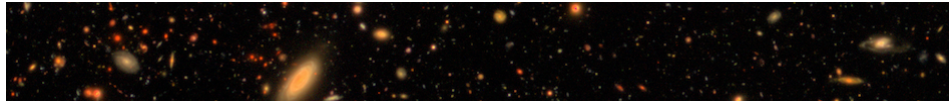


Workshop on Cosmic Indicators of Dark Matter 2024



Report of Contributions

Contribution ID: 1

Type: **not specified**

Cosmic Birefringence and Spacetime-Symmetry Breaking

Tuesday 15 October 2024 13:50 (40 minutes)

Recently, a CMB signal of parity violation in the form of isotropic cosmic birefringence has been claimed, a signal consistent with being produced through an axion-photon coupling. In this talk, I will introduce a generic EFT constructed for studies of spacetime-symmetry breaking. Focusing on the photon sector, I will show that a CPT-odd EFT term in fact takes the same form as an axion-photon coupling and that the non-zero cosmic-birefringence angle produces the strongest constraint on this EFT coefficient to date.

Presenter: NILSSON, Nils A.

Contribution ID: 2

Type: **not specified**

String-wall composites from torus knot vacuum of an axionlike model and the cosmological simulations

Tuesday 15 October 2024 15:00 (40 minutes)

We study a simple axionlike model with two complex scalar fields under global $U(1)$ symmetry. The charge of one scalar field is double the other one. A particular feature of our model is that a vacuum manifold is a torus knot, resulting in the formation of a string-wall network. We numerically show that the network becomes a network of narrow strips of string-wall composites (a “kishimen” network.) We find some of strip loops cut off from the network have the shape of a Moebius strip. The fact that the walls are confined in narrow strips implies that our model is free from the domain wall problem.

Presenter: SAKAKIHARA, Yuki

Contribution ID: 3

Type: **not specified**

Simulations of Ellipsoidal PBH Formation and the impact of Non-Spherical effects on the PBH mass function

Tuesday 15 October 2024 15:40 (20 minutes)

Numerical simulations have been instrumental in advancing our understanding of Primordial Black Hole (PBH) formation and in providing precise estimates of their abundance in the Universe. Traditionally, these simulations have assumed spherical collapse, but indeed, the most realistic initial configuration is an ellipsoid. In this presentation, I will discuss recent findings on non-spherical PBH formation, focusing on its dynamics and the effect of non-sphericities on the threshold of formation. Our results indicate, for the cases tested, that non-spherical effects are crucial when the fluctuation amplitude is near the collapse threshold (critical regime), preventing a significant number of configurations from forming black holes. However, when considering these effects in the statistical estimation of the PBH mass function, their overall impact is minimal.

Presenter: ESCRIVÀ, Albert

Contribution ID: 4

Type: **not specified**

Caustic crossings as a new probe of dark matter

Tuesday 15 October 2024 16:40 (40 minutes)

Caustic crossings are highly magnified individual stars observed in high magnification regions of massive galaxy clusters. The first discovery was reported in 2018, and the number of detections is rapidly increasing thanks to James Webb Space Telescope. In this talk I will discuss how we can use caustic crossings for probing nature of dark matter.

Presenter: OGURI, Masamune

Contribution ID: 5

Type: **not specified**

Interferometric searches for dark matter

Wednesday 16 October 2024 09:30 (40 minutes)

Presenter: WANG, Yikun

Contribution ID: 6

Type: **not specified**

A dark photon search with a gravitational wave detector and the effect of the relative motion of detectors

Wednesday 16 October 2024 10:10 (20 minutes)

The search for dark matter using gravitational wave detectors is attracting significant attention. These detectors have extremely high sensitivity to small displacements, which could be used to detect interactions with ultralight dark matter. Different models predict that dark matter interacts with gravitational wave detectors through various mechanisms. This sensitivity to displacement could allow the detection of dark matter signals. In this study, we discuss methods to detect dark matter signals in data from gravitational wave detectors and how to set upper limits when no candidate signals are found. When estimating these limits, it is essential to account for the relative velocity between the detectors and dark matter. We propose an upper limit estimation method that incorporates this factor.

Presenter: FUJIMORI, Takumi

Contribution ID: 7

Type: **not specified**

Bubble misalignment mechanism for axions

Wednesday 16 October 2024 11:00 (20 minutes)

We study the dynamics of axions at first-order phase transitions in non-Abelian gauge theories. When the duration of the phase transition is short compared to the timescale of the axion oscillations, the axion dynamics is similar to the trapped misalignment mechanism. On the other hand, if this is not the case, the axions are initially expelled from the inside of the bubbles, generating axion waves on the outside. Analogous to the Fermi acceleration, these axions gain energy by repeatedly scattering off the bubble walls. Once they acquire enough energy, they can enter the bubbles. If the axion oscillations are relevant only inside the bubbles during the phase transition, the axion abundance is significantly enhanced compared to models where the axion mass is either constant or varies continuously as a function of temperature. The increase in axion abundance depends on the axion mass, the duration of the phase transition, and the bubble wall velocity. This mechanism results in a spatially inhomogeneous distribution of axions, which could lead to the formation of axion miniclusters. It has potential implications for the formation of oscillons/I-balls, axion warm dark matter, cosmic birefringence, and the production of dark photons.

Presenter: LEE, Junseok

Contribution ID: 8

Type: **not specified**

$n\pi$ ambiguity of cosmic birefringence and its effect on ALP search

Wednesday 16 October 2024 11:20 (20 minutes)

Recently, several papers have reported so-called ‘Cosmic birefringence’, which is a rotation of the direction of linear polarization of CMB. This might be a hint of new physics beyond standard models because the signal means large scale parity violation of this universe. The reported angles of the rotation are ~ 0.3 deg. However, we point out there is a $n\pi$ phase ambiguity for the angle. This ambiguity is trivial from the observational method to determine the angle, but has not been discussed seriously so far though it can impact on the origin of cosmic birefringence. We also discuss how to constrain the ambiguity.

Presenter: NAOKAWA, Fumihiro

Contribution ID: 9

Type: **not specified**

Multi-Field Oscillons in Real-FLS model

Wednesday 16 October 2024 11:40 (20 minutes)

Oscillons are soliton-like localized configurations formed by real scalar fields. In the context of cosmology, it is predicted that oscillons are formed in inflationary models or axion models, and they are suggested to be the origin of gravitational waves or the seeds of primordial black holes. Typically, oscillons are studied in the context of a single real scalar field. However, the existence and nature of oscillons in systems with two or more interacting real scalar fields present an intriguing problem. Recently, such multi-field oscillons have been constructed using two-timing analysis. In this talk, we will apply the two-timing analysis and construct multi-field oscillons within our real-FLS model.

Presenter: OGAWA, Tasuya

Contribution ID: 10

Type: **not specified**

Searches for wavelike dark matter utilizing superconducting qubits

Wednesday 16 October 2024 14:00 (40 minutes)

A DFSZ axion search needs a detector that has an extreme sensitivity to photons. Due to its huge electric dipole moment and intrinsic low noise feature, superconducting qubits are an excellent candidate for the searches. In this talk, we introduce ways to utilize superconducting qubits in dark matter searches and these experimental statuses. Also, we mention a strategy for axion searches by applying magnetic field to superconducting qubits.

Presenter: NITTA, Tatsumi

Contribution ID: 11

Type: **not specified**

Current status of sensitivity improvement of Dark matter Axion search with riNg Cavity Experiment (DANCE)

Wednesday 16 October 2024 14:40 (20 minutes)

Axion and Axion-Like Particles (ALPs) are one of the candidates of dark matter. Axion weakly interacts with photon, electron, proton and so on. Many experiments have been proposed by using the axion-photon conversion under magnetic fields. However, axion has not been observed yet. Our research group has proposed Dark matter Axion search with riNg Cavity Experiment (DANCE). DANCE aims to detect axion without using magnetic fields. The axion-photon interaction induces a rotation of linearly polarized light. We aim to detect the amplified rotation angle with a bow-tie optical ring cavity. In the prototype experiment with a bow-tie optical ring cavity with a round-trip of 1 m (DANCE Act-1), the reflection phase difference between s-polarization and p-polarization on the mirrors of the cavity was observed. This was due to oblique incidence on the mirrors, and we were not able to achieve simultaneous resonance, which is necessary to conduct a sensitive broadband axion search. Recently, we achieved simultaneous resonance by adding an auxiliary cavity to compensate for the reflection phase difference. However, the optical loss on the polarization beam splitter between a bow-tie optical ring cavity and an auxiliary cavity degrades the sensitivity to axion. Also, the measurement results of DANCE Act-1 revealed the time drift of the reflection phase difference between polarizations on the mirrors of the cavity. This makes it challenging to conduct an accurately sensitive axion search. An alternative approach to address these issues is to tune the reflection phase difference between polarizations by tuning laser wavelength. This approach achieves simultaneous resonance by canceling the reflection phase difference between polarizations when light is reflected on the mirrors. In this talk, I will report the detail of simultaneous resonance for DANCE.

Presenter: TAKIDERA, Hinata

Contribution ID: 12

Type: **not specified**

Visualizing high energy particles of extensive air showers with Subaru Hyper Supreme-Cam

Wednesday 16 October 2024 15:00 (20 minutes)

Extensive air showers induced from high-energy cosmic rays provide a window into understanding the most energetic phenomena in the universe. We report on visualizing high energy particles of these showers with the silicon imaging detector Subaru Hyper Supreme-Cam. This method has the advantage of being able to measure individual secondary particles with unprecedented resolution and might be applicable for dark matter search. I will share an interdisciplinary project for combining the Subaru telescope and cosmic ray detectors to decipher details of extensive air showers, dubbed Air-shower Lensing Observatory at High Altitude (ALOHA).

Presenter: FUJII, Toshihiro

Contribution ID: 13

Type: **not specified**

Isotropic cosmic birefringence from an oscillating axion-like field

Wednesday 16 October 2024 15:50 (20 minutes)

We propose a new mechanism for isotropic cosmic birefringence with an axion-like field that rapidly oscillates during the recombination epoch. In conventional models, the field oscillation during the recombination epoch leads to a cancellation of the birefringence effect and significantly suppresses the EB spectrum of the cosmic microwave background (CMB) polarization. By introducing an asymmetric potential to the axion, this cancellation becomes incomplete, and a substantial EB spectrum can be produced. This mechanism also results in a washout of the EE spectrum, which can be probed in future CMB observations. Our findings suggest the possibility that an axion-like field responsible for isotropic cosmic birefringence can also account for a significant fraction of dark matter.

Presenter: MURAI, Kai

Contribution ID: 14

Type: **not specified**

Thermal productions of axion in DFSZ-type axion models

Wednesday 16 October 2024 16:10 (20 minutes)

Axion is a strong candidate for dark matter and has several types of production mechanisms. While the misalignment mechanism has been well-known since long ago and is usually assumed, thermal productions are another attractive possibility. In this talk, we will discuss thermal productions of the axion in DFSZ-type axion models, which involve heavy additional Higgs bosons. Interestingly, in this setup, axion is predominantly produced from the heavy Higgs boson decays, assuming that the reheating temperature of the Universe is larger than the mass of the heavy Higgs bosons. This is a characteristic feature of the DFSZ-type models in the sense that this does not happen in KSVZ-type axion models. Focusing on the axion with a mass of keV to sub-GeV scale, we will discuss how cosmological observations such as X-ray and CMB constrain the model parameter space.

Presenter: SAKURAI, Kodai

Contribution ID: 15

Type: **not specified**

ALP Dark Matter and Measuring its Abundance

Wednesday 16 October 2024 16:30 (40 minutes)

Presenter: JAECKEL, Joerg

Contribution ID: 16

Type: **not specified**

Axion Detection Experiments Meet the Majoron

Thursday 17 October 2024 09:30 (40 minutes)

The majoron is a well-motivated light (pseudo-Nambu-Goldstone) boson associated with the spontaneous breaking of a global lepton-number symmetry. In this letter, we relate the spontaneous breaking scale and its soft-breaking mass by requiring that the majoron is the main component of the dark matter. An electromagnetic-anomalous coupling can be induced by minimally modifying the original majoron model, surprisingly, predicting a parameter region that largely overlaps with the QCD-axion dark matter band. Thus, we expect that axion search experiments meet the majoron.

Presenter: LIANG, Qiuyue

Contribution ID: 17

Type: **not specified**

Recent updates on the morphology of the Galactic Center excess

Thursday 17 October 2024 10:30 (20 minutes)

The Galactic Center Excess (GCE) detected by Fermi-LAT resembles a signal of WIMP dark matter annihilation, although it may also be attributed to a population of millisecond pulsars in the inner Milky Way. I will discuss recent updates in studying the morphology of the GCE. I will show that the bulge model based on the latest VVV survey is consistently favored by data. I will also show that millisecond pulsars contribute to the gamma-ray sky in various region.

Presenter: SONG, Deheng

Contribution ID: 18

Type: **not specified**

Dark matter on small scales

Thursday 17 October 2024 10:50 (40 minutes)

Dark matter is now known to be the vital ingredient for the growth of structure in the Universe, but its nature remains a mystery. Dark matter on the small mass scales, such as within galactic and sub-galactic structures, may well be the key to shedding light on fundamental properties of dark matter and new physics. In particular, revealing dark matter distributions in less massive galaxies is of crucial for testing dark matter models and constraining particle candidate of dark matter. In this talk, I will discuss the current efforts to constrain dark matter distributions in the Milky Way, dwarf spheroidals, and nearby galaxies through dynamical analysis of their currently available data. I will then discuss the future prospects for these dark matter studies.

Presenter: HAYASHI, Kohei