20th Patras Workshop on Axions, WIMPs and WISPs

Monday 22 September 2025 - Friday 26 September 2025

Book of Abstracts

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MAGPI and GALILEO

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I will discuss two new experimental approaches to detect axions. The first, MAGPI, searches for an axion field produced by the Earth or a local test body by looking for the polarization rotation caused by the axion in RF light stored in a cavity. The second, GALILEO, looks for axions in the THz range by looking for the effects of the axion on the index of refraction of a non-linear optical crystal.

Afternoon - 3 / 3

Probing axion-like particles with multimessenger observations of neutron star mergers

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Axion-like particles (ALPs) can be copiously produced in binary neutron star (BNS) mergers through nucleon-nucleon bremsstrahlung if the ALP-nucleon couplings g_{aN} are sizable. Furthermore, the ALP-photon coupling $g_{a\gamma}$ may trigger conversions of ultralight ALPs into photons in the magnetic fields of the merger remnant and of the Milky Way. This effect would lead to a potentially observable short gamma-ray signal, in coincidence with the gravitational-wave signal produced during the merging process.
This event could be detected through multi-messenger observation of BNS mergers employing the synergy between gravitational-wave detectors and gamma-ray telescopes.

In this work, we study the sensitivity of current and proposed MeV gamma-ray experiments to detect such a signal. We find that the proposed instruments can reach a sensitivity down to $g_{a\gamma}$
$gtrsim$few $\times\, 10^{-13}$ GeV^{-1} for m_a
$lesssim 10^{-9}$~eV, comparable with the SN 1987A limit.

Morning - 2 / 4

Superradiant interactions of cosmic noise

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In this talk I will do three things. First, I will outline the conditions under which the interaction rate of inelastic processes with a system consisting of N targets scales as N^2. Second, I will present computations of interaction rates for several weakly interacting particles, including the Cosmic Neutrino Background and Axion Dark Matter, and will explain the underlying physics. Third, I will present a concrete experimental protocol that can extract these effects through quantum observables not relying on net energy transfer. In particular, this protocol will allow to probe QCD Axion Dark Matter, among other cosmic relics, with current technologies in a wide range of parameter space. This work points to a new class of table-top and ultra-low threshold particle detectors.

Morning - 10 / 5

Ultra-deep astronomical imaging to probe the dark matter properties

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The large-scale structure of the Universe strongly supports the hypothesis that collisionless cold dark matter is a good description of the nature of dark matter. However, at the scale of galaxies, this simple hypothesis faces several problems that remain unresolved. In particular, the existence of very low-mass galaxies and their internal structure pose a challenge to this simple dark matter model. In this talk, I will show how the current ultra-deep sky surveys, which are revealing hundreds of such faint galaxies, can help to constrain the various dark matter models with unprecedented accuracy.

Morning - 9 / 6

Searching for Spin-Dependent Exotic Interactions

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The fifth force may arise due to "new physics"beyond the Standard Model. We focus on the spin-dependent fifth forces [1] that are mediated by new particles, such as spin-0 particles (axion and axion-like particles) and spin-1 particles (e.g., light Z'particle or massless paraphoton). These new ultralight particles are also candidates for dark matter and dark energy, and may also break fundamental symmetries. Spin-dependent interactions between fermions have been extensively searched for in experiments, employing methods such as comagnetometers, nitrogen-vacancy spin sensors, and precision measurements of atomic and molecular spectra. Our research involves a theoretical re-assessment of exotic spin-dependent forces. It produces a systematic and complete set of interaction potentials expressed in terms of reduced coupling constants. We conduct an extensive analysis of the existing body of experimental literature on spin-dependent fifth forces, which produces systematic exclusion plots. This leads to a comprehensive understanding of the current research landscape and provide insights for further research.

[1] L. Cong, *W. Ji*, P. Fadeev, F. Ficek, M. Jiang, V. V. Flambaum, H.S. Guan, D. F. Jackson Kimball, M. G. Kozlov, Y. V. Stadnik, D. Budker. Spin-dependent exotic interactions, accepted by RMP, arXiv:2408.15691 (2024). * Equal contribution.

Morning - 10 / 7

The stellar distribution in ultra-faint dwarf galaxies challenges collisionless cold dark matter

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We present evidence for deviations from the collisionless Cold Dark Matter (CDM) paradigm. In the standard model, dark matter (DM) is collisionless and forms halos with dense central cusps, known as NFW profiles. However, observed galaxies often exhibit flat central cores, typical of systems in thermodynamic equilibrium. While baryonic processes can transform cusps into cores in more massive galaxies, these mechanisms fail in low-stellar-mass systems (<1e6 Msun). Therefore, detecting cores in such galaxies suggests that DM may not be entirely collisionless, hinting at its true, unknown nature—possibly fuzzy, self-interacting (SIDM), or warm DM. Traditional dynamical methods can't probe DM in tiny galaxies, so we developed a new technique using stellar photometry alone. Applying it to six Ultra Faint Dwarf galaxies (1e3–1e4 Msun), we found they reside in cored rather than cuspy halos. After excluding other explanations, our results strongly support alternative DM models that go beyond standard CDM assumption.

Morning - 5 / 8

Millimeter-wave probes of axion dark matter with neutron stars

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The axion is a well-motivated hypothetical particle that could account for dark matter. In strong magnetic fields, such as those surrounding neutron stars and magnetars, axions can convert into photons, a process that could, in principle, produce detectable electromagnetic signatures. Traditionally, searches have focused on the microwave (centimeter wave regime), corresponding to axion masses in the micro–electron volt range. Recent research, however, suggests that the lack of observed axion signals in the cm wave spectra of magnetars may be due to a blue shift caused by the plasma conditions in the magnetosphere. This shift would move any axion-induced electromagnetic signal from the cm into the mm wavelengths, making previous searches at lower frequencies less effective.

Given this possibility, the Atacama Large Millimeter/submillimeter Array (ALMA) is an ideal instrument for a new search strategy. ALMA's high resolution and sensitivity in the mm wavelengths make it well-suited to detect such blue-shifted axion signals. The magnetar SGR 1745-2900, located near the Galactic Center, is considered one of the most promising sources for this kind of search due to its strong magnetic field and proximity. In this talk, the recent works based on ALMA observations are going to be discussed, along with their implications on the models.

Afternoon - 1 / 9

Towards post-Gaia new-physics constraints with globular clusters

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Recent Gaia observations, together with advances in the theory of stellar evolution, open up the possibility to study color-magnitude diagrams of Galactic globular clusters with unprecedented accuracy. In particular, lists of cluster members, their metallicity, helium mass fraction, age, distance from the Sun, and reddening can be precisely determined. We present our study of 35 Galactic globular clusters based on the data from Gaia DR3, expected Gaia DR4, and the best ground-based data cross-identified with Gaia. We fit these data by four independent, most developed models and related isochrones, which account for all the essential physical processes. Precise sets of the cluster parameters and member lists will bring novel constraints on axion-like particles and other new-physics scenarios, with first results to be presented in this talk.

Morning - 3 / 10

Axion Polarimeteric Experiment (APE)

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Axion and axion-like particles are hypothesized to interact with photons, inducing a time-varying rotation in the polarization of linearly polarized laser light. This work presents a highly sensitive apparatus designed to detect this rotation. The setup employs a polarimetry configuration featuring two quarter-wave plates inside a Fabry-P´erot cavity, allowing us to investigate unexplored regions of the parameter space, the mass range of (< 10−12 eV), and potentially detect a signal. A further increase in sensitivity can be achieved by using a longer cavity.

Morning - 4 / 11

Stringent Constraints on New Pseudoscalars from Precision Hyperfine Splitting Measurements

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Axion-like particles and similar new pseudoscalar bosons coupled to nucleons and electrons are known to lead to spin-dependent forces in atoms and ions. We argue that hyperfine structure measurements in the hydrogen- and lithium-like charge states are a sensitive probe to this effect. Focusing on specific differences reduces uncertainties due to nuclear effects in hyperfine structure calculations and measurements. Using this, we show that existing measurements on Be provide competitive limits in the region mϕ ≲ 100 keV. We also find that future measurements on Cs and In have discovery potential.

Afternoon - 1 / 12

Cogenesis by QCD axion

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We show how cogenesis of dark matter and baryon asymnmetry can arise from kinetic misalignment of the QCD axion. For this, we work out the DFSZ and KSVZ axion models associated with the type-I seesaw mechanism and the PQ inflation.

Morning - 2 / 13

Influence of Quadratic Axion-Matter Interaction on the Direct Detection of Dark Matter

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Axions and Axion-Like-Particles (ALPs) are theoretically well-motivated candidates for dark matter that, due to their large occupation number, can be described as oscillating classical fields. These particles may feature a quadratic interaction with ordinary matter which can modify the field's dynamics in the vicinity of such objects, inducing a very interesting phenomenology. In this talk, I will treat in a general setting, how the presence of the Earth can modify the sensitivities of direct detection experiments such as CASPEr. I will show the regions of the parameter space with noticeable effects, where current and future experimental sensitivities can be modified. I will also discuss the applicability of the results when the Earth's acceleration is taken into account. For this purpose, I will discuss the time dependence of the field and its relaxation times to stationary configurations.

Afternoon - 4 / 14

0.5 eV QCD Axion Dark Matter

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Even before Wilczek and Weinberg proposed the quantum chromodynamic (QCD) axion as a new light boson beyond the standard model, Sato and Sato used astrophysical considerations to suggest that such a particle cannot have rest-mass energy around 0.5 eV. A decade later, Turner and Raffelt used the observation of the neutrino pulse from supernova 1987A to come to the same conclusion. But a decade ago, Ayala et al. revisited the question and found a hint that 0.5 eV QCD axions might actually be preferred by observations of globular clusters. This talk proposes a simple model for 0.5 eV QCD axions. The model suggests a straightforward production mechanism of 0.5 eV axion dark matter in the early universe. Finally, the best present experimental evidence for 0.5 eV QCD axion dark matter will be briefly sketched.

Morning - 2 / 15

Investigating unidentified sources in the 4FGL-DR4 Fermi-LAT catalog as potential dark matter subhalos

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We explore the prospects for indirect dark-matter (DM) detection through gamma-ray emission from the annihilation of weakly interacting massive particles (WIMPs). Within the ΛCDM cosmological framework, hierarchical structure formation predicts the existence of DM halos and subhalos. If WIMPs constitute DM, they are expected to annihilate within subhalos, emitting gamma rays detectable by instruments such as the Fermi-LAT and Imaging Atmospheric Cherenkov Telescopes (IACTs). Since 2008, Fermi-LAT has cataloged over 7100 gamma-ray sources, with a third lacking clear astrophysical association. This opens the exciting possibility that some of these unassociated sources (unIDs) may actually be DM subhalos below a certain mass threshold, in which they are anticipated to not retain baryons and remain completely as dark satellites from our galaxy, emitting exclusively in gamma rays. Using the 14- years Fermi-LAT catalog (4FGL-DR4), we conduct a search for subhalo candidates among the 2428 unIDs in this catalog. We first implement filtering based on expected properties of DM subhalo to reduce our sample, and then consider different scenarios depending on the level of restriction of these rejection criteria. Through an exhaustive spectral Fermi-LAT data analysis with the Fermipy software, we find that none of the sources significantly prefers a DM interpretation. Then, in the absence of a clear hint, we place conservative constraints on the $\langle\sigma v\rangle - m\chi$ DM parameter space, that allows us to discard thermally-produced WIMP particles below 5 GeV in a conservative scenario, and below 90 GeV when assuming the sensitivity reach of the method.

Morning - 4 / 16

First observation of reactor antineutrinos by coherent scattering with CONUS+

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Neutrinos are elementary particles that interact only very weakly with matter. Neutrino experiments are therefore usually big, with masses on the multi-ton scale. The thresholdless interaction of coherent elastic neutrino-nucleus scattering (CEνNS) leads to drastically enhanced interaction rates, which allows for much smaller detectors. This could open the path for reactor monitoring through the CEνNS channel. Additionally, the study of this process gives insights into physics beyond the Standard Model of particle physics.

The CONUS+ experiment is a project designed to detect for the first time CEνNS in the fully coherent regime with low-energy neutrinos produced in nuclear reactors. For this purpose, four 1 kg point-contact high-purity germanium detectors with extremely low energy threshold of 160 eV were operated at the Leibstadt nuclear power plant (Switzerland), at a distance of about 21 m from the reactor core. The detector performance and first CONUS+ results after one year of data taking will be presented, including the first observation of a CEνNS signal (395+-106) from from reactor antineutrinos. Finally, the future of CONUS+ will be discused, in particular the replacement of three detectors by newer models with higher Ge crystal masses of 2.4 kg each to further improve the sensitivity of the experiment.

Morning - 3 / 17

Stupendously Large Primordial Black Holes from the QCD axion

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The inflationary diffusion of (pseudo-)scalar fields with discrete symmetries can seed the formation of a gas of closed domain walls after inflation, when the distance between degenerate minima in field space is not too far from the inflationary Hubble scale. Primordial black holes (PBHs) can then be formed once sufficiently heavy domain walls re-enter the Hubble sphere. In this scenario, inflation determines a distinctive PBH mass distribution that is rather flat and can thus lead to a sizable total abundance of PBHs, while avoiding some of the downsides of PBH formation from critical collapse. We show that generic QCD axion models, with decay constant close to the inflationary Hubble scale, can yield up to 1% of the dark matter (DM) today in the form of PBHs, while being compatible with isocurvature constraints from Cosmic Microwave Background observations. This occurs for values of axion decay constants around 10^8 GeV, that is the region targeted by axion helioscopes and partially constrained by astrophysical observations. The resulting PBHs have \textit{stupendously} large masses, above 10^11 solar masses, and their existence can be probed by Large Scale Structure observations. Larger PBH abundances can be generated by axion-like particles. Alternatively, in scenarios where isocurvature constraints can be relaxed, we find that the totality of the DM can be produced by the QCD axion misalignment mechanism, accompanied by a O(10^-3) DM fraction in PBHs can act as seeds for the formation of massive black holes at large redshifts, as suggested by recent JWST observations.

Morning - 4 / 18

Searching for Spin-2 Ultralight Dark Matter with Gravitational Wave Detectors

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We explore how gravitational wave detectors, such as LIGO and Virgo, can be leveraged to search for spin-2 ultralight dark matter. These particles are expected to produce a continuous signal, making them well-suited for search methods originally developed for continuous gravitational waves. In this context, we develop a search using the Band Sampled Data framework (a gravitational wave data analysis tool), where we inject the spin-2 signal for a range of masses and coupling constants. We will present the corresponding sensitivities and discuss the potential of these searches in constraining ultralight dark matter.

Morning - 3 / 20

Exploring Dark Matter Features with SNIPE Hunt and DALI Experiments

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Dark matter candidates such as axions and dark photons can generate coherent, oscillating magnetic fields at the Earth's surface, arising from boundary conditions between the conductive Earth and the ionosphere. The Search for Non-Interacting Particles Experiment (SNIPE) collaboration employs a global network of magnetometers in radio-quiet locations to search for these signals. An update on SNIPE's progress, including efforts to enhance sensitivity and extend the search to higher frequencies will be presented. The Dark-photons & Axion-Like particles Interferometer (DALI) is a next-generation experiment designed to detect axion dark matter in the 25–250 μeV mass range. Although optimized as a haloscope for virialized galactic axions, DALI is also sensitive to transient interactions with fine-grained axion streams predicted to pass through the Solar System. A report on DALI's projected sensitivity to these streams will also be presented.

Morning - 1 / 21

Dilaton phase transitions and axion relic pockets

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Pseudo-scalar axions are ubiquitous in high-energy theory, and so are their scalar partners, here called "dilatons", that dynamicalise the corresponding gauge couplings. In this talk, I will discuss the cosmology of dilatons and axions, focussing on the impact of dilaton phase transitions. First, I will show how cosmological dilaton phase transitions can lead to the trapping and compression of axions into "axion relic pockets": regions of false vacuum stabilised from collapse by the pressure of the kinematically trapped, hot axion gas. Axion relic pockets are naturally long-lived and could comprise all dark matter. Their sizes range from point-like to brick-sized, and their masses from intermediate particle-physics scales to asteroid-like. This new dark matter theory is economical: the macroscopic properties of the pockets depend only on a single parameter (the phase transition temperature). I will describe the formation, evolution and present-day properties of axion relic pockets, and outline how their phenomenology is distinct from existing dark matter paradigms. I will briefly outline how laboratory experiments and astronomical observations can be used to probe the theory. Second, I will briefly discuss how a dilaton phase transition involving the strong coupling constant of the Standard Model can make the QCD phase transition first-order, and lead to an intriguing gravitational wave signal in the nano-Hertz frequency range.

Morning - 6 / 22

Axion searches with HTS coated cavities in RADES

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The Relic Axion Detector Exploratory Setup (RADES) Collaboration works on the development of new techniques for axion haloscopes. In 2021 we performed a haloscope axion search performed using a custom-made radio-frequency cavity coated with high-temperature superconducting tape, using an 11.7 T dipole magnet at CERN. We will present the results of the search, after analysing a set of 27 h of data at a resonant frequency of around 8.84 GHz, and a width of width of 554 kHz. No signal excess was observed, and an exclusion limit for an axion-like particle in the region corresponding

to masses from 36.5676 μeV to 36.5699 μeV, was set. We will also present novel preliminary results of a second data-taking campaign featuring an improved acquisition system, a higher-quality factor cavity and updated data taking protocol performed at CERN in 2024.

Morning - 6 / 23

Spin-2 ULDM Detection with Levitated Superconductors

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Ultraprecise mechanical sensors such as magnetically levitated (Maglev) superconductors offer new ways to test the coupling between ultra-light dark matter and electromagnetism. In this talk, building on the ideas and technology proposed for spin-0 and spin-1, I will show how magnetically levitated resonators can be used as detectors for spin-2 dark matter, also known as dark gravitons. I will discuss the peculiarities of the dark graviton effects compared to other dark matter models, and in particular how the dark graviton, described by the Fierz-Pauli Lagrangian, couples simultaneously to matter and light. Both couplings can drive the mechanical motion of the levitated sensor, displacing it from its equilibrium position, an effect which is resonantly amplified when the Compton frequency of the dark matter matches the trapping frequency of the sensor. Finally, I will present a specific experimental setup that is sensitive to dark graviton dark matter and conclude with a forecast for its sensitivity.

Afternoon - 2 / 24

Axion Quark Nuggets as strongly interacting DM objects in Earth's atmosphere

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In this talk I want to discuss the (unorthodox) scenario when the baryogenesis is replaced by a charge separation process in which the global baryon number of the Universe remains zero. In this, the so-called axion quark nugget (AQN) dark matter (DM) model the unobserved antibaryons come to comprise the dark matter in the form of nuclear density nuggets. In this talk I specifically focus on two recent papers, see below. I will argue that a number of mysterious and puzzling observations recorded on Earth could be originated from this new paradigm when the DM is represented by strongly interacting objects. I will also argue that the Ball Lightnings which have been observed for centuries (however, this phenomenon has never been explained by known physics) is in fact a profound manifestation of the same DM physics.

1. A. Zhitnitsky and M. Maroudas,
"Mysterious Anomalies in Earth's Atmosphere and Strongly Interacting Dark Matter,"
[arXiv:2405.04635 [hep-ph]].
2. A. Zhitnitsky, "Ball Lightning as a profound manifestation of the Dark Matter physics,"
[arXiv:2502.02653 [hep-ph]].

Morning - 7 / 26

DALI: A Novel Magnetized Phased Array Haloscope for Axion Dark Matter Searches

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DALI (Dark-photons & Axion-Like particles Interferometer) is a next-generation haloscope experiment targeting the 25–250 μeV mass range in the search for axion dark matter. It introduces a novel experimental approach based on a magnetized phased array (MPA) architecture and a tunable resonator, offering significant advantages over conventional designs.
This presentation will outline the DALI concept and its scientific objectives, with a focus on the development and testing of a proof-of-principle prototype. We intend to present initial experimental data, performance benchmarks, and the optical design and simulation results for the full antenna array —a critical component for achieving broadband sensitivity across the targeted mass range.
The talk will highlight both the conceptual innovation and the current experimental progress of the DALI program and discuss its potential contribution to the direct detection of axion dark matter in a largely unexplored spectral range.

Afternoon - 2 / 27

Angular redshift fluctuations as an alternative cosmological probe in times of cosmic tensions

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In this talk I will introduce angular redshift fluctuations (ARF), a novel cosmological observable that, contrary to other standard probes that measure the counts and the shapes of galaxies, looks at the galaxies' redshifts and their fluctuations when projected under any given redshift shell. I will show ARF are found to be extremely sensitive to radial peculiar velocities, and also to the underlying density field. This means they are sensitive to the baryonic acoustic oscillations (BAO), and together with standard 2D angular clustering, ARF provide a unique window to the BAO in angle and redshift space. ARF have been applied to BOSS spectroscopic, measuring the growth rate and setting very strong constrains on deviations from general relativity. They have also been applied on photometric galaxy surveys like QUAIA, unveiling ARF's great complementary power ni searches for the non-Gaussianity parameter $f_{\rm NL}$. I will conclude by discussing ARF's potential to provide alternative measurements of key cosmological and fundamental parameters when combined with 2D clustering and CMB lensing.

Morning - 1 / 28

Light dark matter search in XENONnT

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The XENONnT experiment aims at the direct detection of dark matter. It employs a dual-phase xenon time projection chamber and has been operating at Laboratori Nazionali del Gran Sasso (LNGS) in Italy since 2020, with an active mass of 5.8 tonnes.

XENONnT is most sensitive to weakly interacting massive particles (WIMPs) above 6 GeV/c^2 scattering off xenon nuclei by detecting both scintillation (S1) and ionization (S2) signals. However, requiring an S1 signal limits sensitivity to low-mass dark matter. By performing analyses that use only the S2 signal, combined with background discrimination strategies, the experiment can extend its reach into the sub-GeV regime and probe lighter dark matter.

This talk will present the current status of XENONnT, its potential to be sensitive to low-energy recoil, and the latest results.

Morning - 5 / 29

Investigating the isolated S1 backgrounds in the LUX-ZEPLIN (LZ) experiment

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The LUX-ZEPLIN (LZ) experiment features a dual-phase xenon time projection chamber designed to detect weakly interacting massive particles (WIMPs) with unprecedented sensitivity. Among its backgrounds, scintillation-only events are particularly challenging to study due to their small size and consequential poor spatial reconstruction; yet, they play a significant role by contributing to accidental coincidence backgrounds that can obscure WIMP-like signals.

We investigate the nature of these scintillation-only events by leveraging the double photoelectron effect in vacuum ultra violet (VUV) photomultipliers. By distinguishing xenon-induced VUV light from potential non-xenon (non-VUV) sources, such as fluorescence from detector materials, we aim to identify the underlying mechanisms responsible for these events. This research not only contributes to the broader effort to refine background models, ultimately improving the reliability of the LZ experiment's search for dark matter, but will also be of fundamental importance for the design and optimisation of future detectors, paving the way for the next generation of dark matter experiments.

Afternoon - 1 / 30

Electron capture decays in the LUX-ZEPLIN (LZ) experiment

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Electron capture (EC) decays of Xe-125 and Xe-127 constitute a known background in dark matter searches with dual phase xenon time projection chambers (TPCs) such as the LUX-ZEPLIN (LZ) experiment. The signals produced by these processes present a lower charge-to-light ratio compared to β-particle interactions of the same energy, which is attributed to enhanced recombination at the EC site as a consequence of denser ionisation tracks created by the Auger effect. Double electron capture (DEC) decays of Xe-124 are the rarest radioisotope decays ever measured, and these present additional ionisation suppression in LXe TPCs from even more complex decay-site topologies. In this talk I will present the measurements of ionisation yield attenuation in Xe-125 and Xe-127 EC decays in LZ and how these were used to infer DEC charge yields used to constrain the Xe-124 LL- and LM-capture decays observed in the recent WIMP search.

Morning - 5 / 31

Axions and the formation of supermassive black holes at cosmic dawn

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Axion dark matter thermalizes by gravitational self-interactions and forms a Bose-Einstein condensate. It is shown that the rethermalization of the axion fluid during the initial collapse of large scale overdensities at cosmic dawn transports angular momentum outward sufficiently fast that black holes form with masses ranging from approximately 10^5 to a few times 10^{10} $M_\odot$.

Afternoon - 1 / 32

Searches of Axions/ALPS with (Baby)IAXO

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The International Axion Observatory (IAXO) is a new generation axion helioscope aiming at a sensitivity to the axion-photon coupling of gaγ a few×10-12GeV-1, i.e. 1-1.5 orders of magnitude beyond the one achieved by CAST, currently the most sensitive axion helioscope. The main elements of IAXO are a large superconducting toroidal magnet with eight bores, x-ray focusing optics and low background detectors. An intermediate helioscope on the way to IAXO, called BabyIAXO, with the aim of testing the new technology for the full scale experiment, is now being built and will be located at DESY. The design of all components and assembly procedures is very advanced. In spite of socio-political problems worldwide causing a delay for the fabrication of the magnet, we have made very significant progress and are confident that the magnet now be built in due time. Currently, we are discussing the strategy to perform important tests in the final BabyIAXO location at DESY on different instrumentation and mechanics in preparation to BabyIAXO while waiting for the magnet to
be in place. Once completed, BabyIAXO will be able to test gaγ down to 2×10-11 GeV-1, an improvement of the signal to noise ratio of a factor of 100 w.r.t. to CAST. In case of IAXO the SNR improvement would be about 4-5 orders of magnitude. In addition, already with BabyIAXO it will be possible to search for evidence of axion-electron and axion-nucleon coupling in the Sun. Moreover, installing cavities or antennas in the magnet bores will turn BabyIAXO into an axion haloscope, sensitive to dark matter axions in different mass ranges. We will discuss the physics reach of BabyIAXO and present the enhanced sensitivity for axion discovery
which will be possible to obtain with the full scale IAXO.

Morning - 3 / 33

Thermal design and modeling of the Tenerife Microwave Spectrometer: towards high precision spectral measurements of the microwave sky at 10-20GHz

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According to the ΛCDM model, spectral distortions of the CMB from a perfect blackbody shape are expected. The COBE experiment was the first to measure the absolute spectrum of the CMB in the 1 to 95 cm^{-1} frequency range, but it did not detect any deviations from a pure blackbody. Absolute measurements of the CMB at longer wavelengths than those covered by COBE have been performed by a few ground-based and balloon-borne experiments. Notably, ARCADE2 detected an unexplained excess of radio emission with a synchrotron-like spectrum —the so-called radio synchrotron background —which might potentially be explained by dark matter models (e.g., axions, sterile neutrinos, superconducting cosmic strings, etc.).

The Tenerife Microwave Spectrometer (TMS) is a new ground-based microwave experiment to be installed at the Teide Observatory (Tenerife, Spain). TMS will take precise measurements of the absolute sky spectrum (at the level of uK) in the frequency range between 10 to 20 GHz, with the sensitivity to characterize the spectral dependence of the radio synchrotron background. TMS uses a pseudo-correlation scheme, similar to the Low Frequency Instrument (LFI) on board the PLANCK satellite, which simultaneously compares two input signals, one coming from the sky, and one coming from a stable reference black body load at cryogenic temperatures. At the output of the radiometer, the difference between both signals will be recorded and deviations from the blackbody curve will be measured.

TMS requires a detailed characterization of every part of the radiometric chain to predict the possible systematic effects that will impact the final measurements and to design the calibration strategy. In this talk, we present a detailed forecast of the instrument performance, by obtaining the temperature contributions due to the non-ideality of the radiometric components. These results are used, together with a Jones matrix analysis, to perform realistic simulations of the instrument to consolidate the calibration scheme.

Morning - 10 / 34

A Novel Spiral-Based Tuning Mechanism for Plasma Haloscopes

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The plasma haloscope is a promising variant of cavity haloscope for axion dark matter searches, employing an array of equidistant metallic wires. ALPHA is a global collaboration dedicated to the development and operation of such plasma haloscope experiments. The resonant frequency of these wire-array cavities is primarily determined by the inter-wire spacing, enabling access to higher mass ranges with minimal volume loss. Tuning the frequency typically requires mechanically complex systems to adjust all wire spacings simultaneously. In this work, we present a novel tuning mechanism inspired by spiral geometry, enabling frequency tuning through a single rotational motion. I will present electromagnetic simulations and experimental measurements demonstrating the effectiveness of the spiral-based design and discuss its potential for implementation in ALPHA.

Morning - 3 / 35

FAxE: A Gigahertz Fabry-Perot Resonator for Axion Dark Matter Detection

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Conventional closed resonator haloscopes become increasingly ineffective at probing axion masses above $\sim 40\mu\mathrm{eV}$, as their effective volume scales as $V_{\mathrm{eff}} \propto 1/m_a^3$, leading to a steep decline in signal power with increasing mass. Open resonators, in contrast, relax the transverse boundary conditions, resulting in a more favorable scaling of $V_{\mathrm{eff}} \propto 1/m_a$. This can significantly improve sensitivity at higher axion masses, if diffractive losses are kept low.

In this talk, I will introduce the Fabry-Pérot Axion Experiment (FAxE), a proposed haloscope targeting axion dark matter in the 30–70 GHz range using a Fabry-P\'erot–type open resonator. FAxE is designed to achieve an effective volume on the order of $\mathcal{O}(10^3)\lambda^3$, while maintaining a high quality factor. This is enabled by a graded-phase mirror design, which suppresses diffraction losses more effectively than traditional spherical designs, without compromising mode volume.

I will outline the FAxE design concept, discuss simulation and prototyping results, and describe the key technical milestones required to achieve sensitivity at the level of the QCD axion in the targeted mass range.

Morning - 2 / 36

Highlights from the NA64 experiment

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NA64 is a fixed target experiment at the CERN Super Proton Synchrotron accelerator searching for Dark Sectors employing high-energy electron, positron, hadron, and muon beams. This talk reports the latest results on sub-GeV Dark Matter searches with the 2016-2022 statistics. With the new data, NA64 is starting to probe for the first time the very interesting region of parameter space motivated by benchmark Light Dark Matter models. The experiment can also probe a variety of well-motivated New Physics scenarios that will be briefly covered in this talk, such as ALPs, inelastic DM, B−L, and Lμ−Lτ Z′ boson searches. Moreover, in this contribution, we will also present the first results of NA64 running in positron and muon modes as well as the future plans of the experiment.

Morning - 7 / 37

ANAIS-112 Experiment: searching for the WIMP wind under the Pyrenees to solve the DAMA/LIBRA puzzle

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The particles composing the dark matter are thought to be distributed in haloes around the galaxies and then, they can be detected on Earth-based very sensitive instruments if they couple to normal matter other than gravitationally. Direct dark matter searches sensitivity has been steadily improving for about forty years, profiting from the development of new detection strategies, application of a variety of target nuclei, and improving the ultra-low-radioactive background techniques. The DAMA/LIBRA experiment claim the detection of the galactic dark matter, relying on the observation for more than twenty years of an annual modulation in the detection rate of their NaI(Tl) detectors. The observed modulation shares all the features expected for the galactic dark matter signal in the standard halo model. However, no other experiment has observed any hint supporting this interpretation of the DAMA/LIBRA result, and it seems very difficult to reconcile it with the plethora of negative results from different experiments (using different targets and techniques). However, results from the most sensitive experiments cannot be compared with DAMA/LIBRA result in a model-independent way because of the unknowns and uncertainties in the model parameters involved in such a comparison. Only recently, beyond three-sigma sensitivity to DAMA/LIBRA result is at hand using the same target material, NaI, which allows to cancel all the signal dependences on the particle dark matter model and the dark halo model, and then, it enables a model independent testing. The status of the testing of the DAMA/LIBRA result, as well as a revision of the possible systematics involved and the sensitivity prospects for the near future will be presented with the focus on the ANAIS-112 experiment, taking data at the Canfranc Underground Laboratory, Spain, since August 2017.

Afternoon - 3 / 38

Data Analysis for the ALPS II Experiment's Initial Science Campaign

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The Any Light Particle Search II (ALPS II), a light-shining-through-a-wall experiment located in Hamburg, Germany at the Deutsches Elektronen-Synchrotron (DESY), completed its first science runs in early 2024. The experiment principally searched for axions and axion-like particles in two data-taking stretches deemed a "scalar" run and a "pseudoscalar" run. The analysis of the data from these runs is discussed here. Specifically, the discussion will include the calibration into coupling strength sensitivity, the statistical analysis, and the treatment of the stray-light background. Finally, the results from the runs are presented with their implications for axions and other potential Beyond-Standard-Model particles, such as massive gravitons and dark photons.

Morning - 5 / 39

Sensitivity of CTAO to axion-like particles from blazars: a machine learning approach

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Blazars are a class of active galactic nuclei, supermassive black holes located at the centres of distant galaxies characterised by strong emission across the entire electromagnetic spectrum, from radio waves to gamma rays. Their relativistic jets, closely aligned to the line of sight from Earth, are a rich and complex environment, characterised by the presence of strong magnetic fields over parsec-scale lengths. Owing to their cosmological distance from Earth, these sources serve as ideal targets to probe non-standard gamma-ray propagation. In particular, axion-like particles (ALPs) could be detected through their coupling to photons, which enables ALP-photon conversions in external magnetic fields, leading to distinct signatures in the blazars'gamma-ray spectra. The Cherenkov Telescope Array Observatory (CTAO), with its enhanced energy resolution and point-source sensitivity with respect to present ground-based gamma-ray telescopes, will be a next-generation instrument very well fit to probe such features. In this contribution, we explore an approach based on the use of machine learning (ML) classifiers and compare it to the standard method of likelihood-ratio test, previously applied in CTAO sensitivity studies for ALP signatures. Our preliminary 2σ exclusion regions on the ALP parameter space suggest that both techniques yield consistent results, with the ML-based method offering broader coverage and potentially extending the CTAO sensitivity beyond existing constraints.

Morning - 5 / 40

DOSUE-RR Experiment: The First Direct Search for Dark Photon Dark Matter at 1 meV Mass

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Dark photon is one of the candidates for cold dark matter, predicted by specific models of string theories and high-scale inflation models. Dark photons interact with ordinary photons via the coupling constant χ. Owing to this interaction, the dark photons convert into millimeter-wave light at electromagnetic boundaries, such as the surface of a metal plate. The frequency of the conversion photon corresponds to the mass of the dark photon because of energy conservation ($h\nu \simeq mc^2$). For example, a signal at 240 GHz corresponds to the mass of 1 meV.

To detect the conversion light from the dark photon in various frequency bands, we, the DOSUE-RR collaboration, have developed cryogenic millimeter-wave receivers. We have already searched for conversion photons in the 10–26.5 GHz range. Since there is still an unexplored range around O(100 GHz), we are focusing on the frequency range of 170–260 GHz as the next target.

As a pilot experiment for the high frequency range, we developed a cryogenic receiver equipped with a Superconductor-Insulator-Superconductor (SIS) mixer to achieve low noise (around 150 K). We then searched for dark photons with a mass at 1 meV, corresponding to the frequency range 242.9493–242.9503 GHz. In this workshop, we will present our results of the pilot experiment and future plans to cover the full range of 170−260 GHz.

Afternoon - 4 / 41

Exploring Axion Dark Matter with Quantum Sensors in the RADES Collaboration

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The RADES (Relic Axion Detector Experimental Setup) collaboration is dedicated to the search for axions, hypothetical particles that are compelling dark matter candidates and a natural solution to the strong CP problem in QCD. Our approach focuses on haloscope detectors, a well-established technique that exploits the axion-photon conversion in strong magnetic fields and resonant cavities. Over the past years, RADES has pioneered the development of novel microwave resonator arrays tailored to axion detection, with experimental campaigns carried out at facilities such as CERN's CAST experiment and SM18 magnet test facility, and foreseen in future axion helioscopes like BabyIAXO.

Building upon this foundation, our current efforts are directed toward integrating quantum sensing technologies to significantly improve sensitivity. The DarkQuantum ERC Synergy Grant was awarded to researchers of the RADES collaboration to foster the development of non-demolition quantum sensors based on superconducting transmon qubits for axion searches. These sensors allow the detection of single microwave photons generated by axion conversions inside resonant cavities without absorbing them, thus preserving the signal and enabling repeated measurements, making the result robust against spontaneous quantum errors.

In this talk, I will present an overview of the RADES collaboration and our motivation for pursuing axions as a primary dark matter candidate. I will briefly summarize our haloscope developments and introduce our latest advances in quantum sensing. Notably, I will report on results from our first working prototype of a quantum non-demolition readout system using a transmon qubit coupled to a 3D microwave cavity. These results mark a promising step toward implementing quantum-limited axion searches and could pave the way for a new generation of dark matter detectors.

Morning - 8 / 42

Grenoble Axion Haloscope (GrAHal) projects in collaboration with DMAG/IBS for Axion Dark Matter Search

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A collaboration between three main laboratories of CNRS, Université Grenoble-Alpes and DMAG/IBS in South Korea (ex-CAPP) is bringing together key expertises to build and operate several haloscopes for axion dark matter searches with unprecedented sensitivity. Based on existing infrastructures at Grenoble like the 9 T/43 T modular hybrid magnet of LNCMI recently put in operation up to 8.5 T/42 T as a first step, the technological know-hows of Institut Néel to develop novel quantum amplifiers together with ultralow temperature cryogenics (< 50 mK) and of DMAG/IBS for RF cavities, GrAHal-DMAG plans to reach beyond state-of-the art sensitivities focusing first to the 1-3 micro-eV axion mass range (300-600 MHz) with a large bore RF cavity in copper as well as around 52.77 micro-eV (12.76 GHz) with a high temperature superconducting one.

Afternoon - 6 / 43

Towards a Measurement of Vacuum Magnetic Birefringence with ALPS II

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The vacuum magnetic birefringence (VMB) effect is a long-standing prediction of quantum electrodynamics (QED) that has yet to be observed in a laboratory setting. The ALPS group at DESY intends to measure this elusive phenomenon for the first time by leveraging the unique infrastructure of the ALPS II experiment. The setup will measure the differential optical path length between two orthogonally polarized laser beams as they traverse a modulated magnetic field generated by 24 superconducting dipole magnets. To amplify the expected signal, a 250-meter-long high-finesse optical cavity will be employed. With over 200 meters of 5.3 T magnetic field, this configuration can achieve an expected VMB signal strength orders of magnitude larger than previous experimental effort. Reaching the sensitivity required to observe the QED-predicted birefringence would represent either a landmark confirmation of QED or an indication of physics beyond the Standard Model. Here, I will present our ongoing characterization of birefringence noise in our control and readout scheme using a 19-meter test cavity and outline the forthcoming steps towards a full VMB measurement with the ALPS II magnet string.

Morning - 8 / 45

WISP searches on a fiber interferometer under a strong magnetic field (WISPFI)

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WISPFI (WISP Searches on a Fiber Interferometer) is a novel table-top experiment designed to detect photon-axion conversion using resonant mixing. The experiment employs hollow-core photonic crystal fibers (HC-PCF) to fulfill the resonant condition, which can be precisely tuned by adjusting the gas pressure within the fiber. This technique enables the probing of an unexplored axion mass range (28 meV–100 meV) and achieves the two-photon coupling levels anticipated for the QCD axion.

The experiment is based on a partial-free space Mach-Zehnder-type interferometer that measures the photon reduction in the sensing arm, which is positioned within an external magnetic field. Two lasers at different wavelengths of 1535nm and 1570nm are used together with an optical switch to modulate the axion signal at a frequency of 100kHz. Latest advancements are presented concerning the data-taking of the currently built prototype with the application of an external magnetic field of 2T and measuring at normal lab conditions (T=293K, P=1.013bar).

Afternoon - 5 / 46

Understanding Dwarf Galaxies to Understand Dark Matter

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The large-scale structure of our Universe is well described by a model in which matter is predominantly Cold Dark Matter (CDM). While CDM was initially thought to have trouble reproducing observations of dwarf galaxies, it has generally become accepted in the last decade that a proper treatment of the gas and stars (baryonic matter) can alleviate those tensions. However, the models of energetic "feedback" from stars that have solved some of the tensions in CDM are now running into trouble solving new problems, specifically the "diversity of rotation curves" problem. The diversity of rotation curves has led to renewed interest in self-interacting dark matter (SIDM) to explain observations. In this talk, I will highlight the degeneracy between galaxy formation and dark matter at dwarf galaxy scales, and progress toward disentangling the two.

Morning - 8 / 47

The ALPS II Optical System

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The Any Light Particle Search II (ALPS II) is a 'light-shining-through-a-wall' experiment currently running at DESY in Hamburg, Germany, searching for axions and axion-like particles. 'light-shining-through-a-wall' experiments use a strong laser to shine light through a strong magnetic field to convert a fraction of the light into axions. The unconverted light is blocked by a wall while the axions pass through. A fraction of the axions are then reconverted to photons within another magnetic field and are measured on the other side of the wall, thus confirming a conversion-reconversion process has occurred. On site, the experiment employs a high-power laser system, a $230\,\mathrm{m}$ long magnet string consisting of 24 HERA dipole magnets, a complex optical system including a $122\,\mathrm{m}$ long high finesse cavity, and a detector system with capabilities to measure ultra-weak signals on the order of photons per day after the wall. After a successful first science run, the experiment is currently in an upgrading phase. This upgrade includes the commissioning of a second high finesse cavity as well as upgrades to the optical system to suppress background signals. This talk will give an overview of the optical system, report on the current status of the upgrade commissioning, as well as give an outlook on the experiment.

Morning - 6 / 48

Axion, ALP, and HFGW Searches Across Complementary Experimental Frontiers

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We present a unified program of complementary experiments targeting axions, axion-like particles (ALPs), and high-frequency gravitational waves (HFGWs) across a broad range of masses and couplings. The WISPFI experiment probes ALPs in the 28 to 100 meV range using resonant photon-axion conversion in a fiber-based interferometer with hollow-core photonic crystal fibers inside a magnetic field. The WISPLC setup, currently operating in broadband mode, detects axion-induced toroidal magnetic fields via a pickup loop in a 7 T solenoid, reaching a preliminary sensitivity down to $g_{a\gamma\gamma} \approx 10^{-11}$ GeV^{-1} for axion masses between around 10^{-11} eV and 10^{-7} eV. Building upon this design, GraviLC—under construction—uses a modified pickup loop in a 14 T solenoid warm-bore magnet to search for electromagnetic imprints of HFGWs in the ~10 kHz to 10 MHz range, ranging from transient signals from primordial black holes and stochastic background. A matched-filtering analysis pipeline with real-time convolution will enable enhanced sensitivity to short-duration signals. ADAMOS, a fixed-frequency cavity experiment under development, aims to explore three distinct axion signatures: cold dark matter at high frequencies, daily modulations from directional effects, and transient enhancements from streaming axions. It employs a high-Q thin-shell cavity resonator operating near 20 GHz installed in the same 14 T warm-bore magnet, and featuring a continuously calibrated RF readout designed to suppress gain drifts and systematics. Finally, the proposed WISPCAV experiment will integrate a graphene Josephson junction (GJJ) bolometer into a superconducting cavity at $\sim$8.7 GHz, leveraging the ultra-low heat capacity and fast response of graphene for single-photon thermometric detection. Together, these efforts provide broad and complementary coverage of weakly interacting slim particles (WISPs) and gravitational phenomena beyond the Standard Model.

Afternoon - 4 / 49

Axion-like Particles in the Very-High-Energy Sky: From MAGIC to CTAO

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Axion-like particles (ALPs) are promising candidates for new physics beyond the Standard Model, motivated by their potential to resolve one of the greatest mysteries of the Universe: Dark Matter (DM). Their ability to oscillate into photons in the presence of an external magnetic field, leads to expected signatures imposed on the observed photon spectra of astrophysical sources. In gamma-ray astronomy, photon-ALP oscillations can lead to observable effects across a broad energy range, from GeV to TeV. These effects may help explain irregularities in photon spectra and the apparently anomalous transparency of the Universe to very-high-energy (VHE) gamma rays.
For ALP masses in the neV range and magnetic field strengths of O(μG), photon-ALP oscillations are most prominent in the GeV regime. This energy range lies at the lower end of the sensitivity for the future Cherenkov Telescope Array Observatory (CTAO), driven by the Large-Sized Telescopes (LSTs) subarray. It is also covered by the MAGIC telescopes, making them both particularly well-suited to probe ALP effects in the VHE gamma-ray domain.
A recent study conducted by the MAGIC collaboration using the data of the radio galaxy NGC1275 collected via observations of the Perseus cluster has set the strongest constraints to date on the ALPs masses from 40-80 neV. A currently underway project aimed at analyzing blazar data taken by the first Large-Sized Telescope (LST-1) of CTAO will be the first one to derive combined constraints on the ALPs parameter space from VHE observations of multiple sources.

Looking ahead, preliminary studies performed with the CTAO support its potential to explore previously inaccessible regions of the parameter space thanks to its unprecedented sensitivity, energy coverage, and improved resolution. With its dual-site configuration, CTAO will enable high-statistics, multi-source studies across the entire VHE sky, and allowing us to further advance our understanding of photon-ALP mixing in the high-energy Universe.

Monday / 50

ADAMOS: Axion Daily Modulation Searches for Dark Matter at 20 GHz

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We present ADAMOS, a new microwave haloscope experiment under development at the University of Hamburg, aimed at searching for dark matter axions in the 20 GHz frequency range. The experiment centers on a novel "thin-shell"annular cavity resonator designed to maintain a large detection volume at high frequencies—an approach that addresses longstanding challenges in haloscope scaling. A proof-of-principle prototype of the cavity is currently under construction, following extensive eigenfrequency and frequency-domain simulations to validate and optimize the design.

The resonator will be installed in an existing 14 T superconducting magnet and coupled to a highly sensitive, continuously calibrated RF readout chain. This system incorporates real-time in-situ calibration to suppress temperature-dependent gain drifts—an improvement inspired by the CAST-CAPP campaign. ADAMOS will simultaneously search for three distinct classes of axion signals: (1) conventional cold dark matter (CDM) axions, (2) relativistic axions from Axion Quark Nugget (AQN) annihilations, which are expected to exhibit daily modulation, and (3) transient enhancements from streaming dark matter.

By targeting this unexplored frequency regime with a robust and versatile detection strategy, ADAMOS aims to open new discovery channels and position the University of Hamburg as a leading center for axion and dark matter research

Afternoon - 1 / 51

Status of the CRESST-III Experiment

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The CRESST-III (Cryogenic Rare Event Search with Superconducting Thermometers) experiment is looking for the direct detection of dark matter particles via their scattering off target nuclei in cryogenic detectors, operated at mK temperatures. Energy thresholds of O(10 eV) allow for the search of sub-GeV dark matter masses, making CRESST one of the leading experiments in the low-mass DM regime. At energies below ~ 200 eV an unexpected rise of events is observed, exceeding the expected background rates. This "Low Energy Excess" (LEE) is limiting the further improvement of low-mass sensitivity in CRESST. The primary focus of current data taking campaigns is therefore fully dedicated to study the origin of the LEE. We present an overview of the CRESST-III experiment

and report on both, new DM results as well as recent observations of the LEE. Furthermore we give an update on R&D and future plans for a CRESST upgrade.

Morning - 5 / 52

Observing the string axiverse

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String theory models generically lead to a large number of axion-like particles (ALPs), known as the string axiverse. I will discuss the possible astrophysical and experimental signatures of the string axiverse, and how the phenomenology of many ALP systems differs from that of a single ALP or axion.

Morning - 2 / 53

Dark matter search results with a 0.2 ng detector

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At DESY in Hamburg, the ALPS group is developing detection systems for rare event searches based on superconducting Transition Edge Sensors (TES) together with international partners. In addition to the activities regarding an application within the ALPS II experiment, the TES platform at DESY has been adapted for direct detection of sub-MeV dark matter (DM) particles. Profiting from their low noise, high detection efficiency and impressive energy resolution, TES are already employed as readout to search for DM in several experiments with solid-state targets. In contrast, in our experiment, we use the TES not only as a sensor, but also as a target when searching for DM interactions, using the superconducting film of our TES. With our detection setup consisting of SQUID-coupled TES detection modules originally optimized for 1064 nm photon pulses we can show for the first time that this approach is viable for independent direct DM searches. With its sub-eV sensitivity our TES is sensitive to sub-MeV DM-electron scattering and low-mass parameter space inaccessible by most DM-nucleon scattering experiments. In this contribution, we will present results of the first measurement campaigns with two different TES modules including the resulting limits on dark matter interactions. In addition, we will give an outlook regarding how this approach could be extended for an even better reach in sensitivity.

Afternoon - 5 / 54

Status of the Cosmic Axion Spin Precession Experiment

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First proposed to solve the strong CP problem, axions are also plausible candidates for dark matter as they are expected to have a mass and as they have seemingly weak interactions with known particles. The Cosmic Axion Spin Precession Experiment (CASPEr) encompasses multiple projects using nuclear magnetic resonance (NMR) to search for axion dark matter. The CASPEr-Gradient Low Field (LF) and High Field (HF) apparatuses investigate the interaction between nuclear spins and the gradient of the axion classical field oscillating at the Compton frequency $m_a c^2/\hbar$. The two instruments use superconducting magnets generating up to 0.1 T and 14.1 T and detect the axion-induced nuclear precession thanks to respectively a superconducting quantum interference device (SQUID) and a tunable LC circuit allowing in principle detection in the 1 kHz to 4 MHz and 1 kHz to 600 MHz mass range. Here, we present the current status of the CASPEr-Gradient experiments, including the recent commissioning measurement of the CASPEr-LF setup and the characterization of the newly-built CASPEr-HF as well as progress toward the use of a hyperpolarized ^{129}Xe sample. These efforts constitute an important step toward the exploration of uncharted regions of the axion dark matter parameter space.

Morning - 8 / 55

Machine Learning–Enabled Searches for Axions and Gravitational Waves with DMRadio-50L and ABRACADABRA

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The DMRadio program is developing a suite of experiments to probe QCD axions in the sub-1 μeV mass range, a theoretically motivated regime with implications for grand unified theories and pre-inflationary cosmology. The first of these, DMRadio-50L, is undergoing commissioning and targets axion masses from 5 kHz to 5 MHz. Accessing this low-mass QCD axion regime poses unique experimental challenges, requiring high-field magnets, ultra-sensitive readout, and advanced data analysis. To address these challenges, we implement machine learning–based denoising techniques developed in the ABRACADABRA (ABRA) experiment and integrate them into a flexible analysis framework that leverages statistical inference and signal processing to enhance sensitivity. These tools not only improve axion detection capabilities but also expand the scientific reach of DMRadio-50L. In particular, data from the same detector can be reanalyzed to search for high-frequency gravitational waves and other non-standard signals as demonstrated on the ABRA-10cm. Current results from DMRadio-50L and ABRA-10cm will be presented, with a focus on how machine learning enhances sensitivity across these complementary searches.

Morning - 9 / 56

The DELight Experiment

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As direct detection experiments continue to tighten constraints on heavy WIMPs, the low-mass region of the dark matter (DM) parameter space remains largely unexplored. Detecting Light Dark Matter (LDM) requires both sub-keV energy thresholds and large exposure. While solid-state detectors can achieve energy thresholds on the order of 10 eV, their limited target mass restricts the achievable exposure.
The "Direct search Experiment for Light dark matter" (DELight) is designed to address this challenge by employing superfluid helium-4 as a target material. Helium offers several advantages: its low nuclear mass and intrinsic radiopurity make it ideal for low-threshold experiments, and enables scalable detector designs. Additionally, it provides both photon and quasiparticle signal channels, allowing for discrimination between interaction types. DELight will utilize Magnetic Micro-Calorimeters (MMCs), which offer excellent energy resolution and a detection threshold of a few eV. In its initial phase, with an exposure of 1 kg×d and a threshold of 20 eV, DELight is expected to probe previously inaccessible regions of the LDM parameter space, achieving a projected sensitivity below 10^{-39} cm² at a DM mass of 200 MeV/c² for masses under 100 MeV/c². This contribution will outline the working principles of the DELight experiment and provide an overview of the recent developments towards its realization.

Morning - 9 / 57

Phenomenology of axion-like particle emission by type Ia supernovae

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Axion-like particles (ALPs) are a class of hypothetical bosons beyond the standard model of particle physis, which are
very weakly-interacting and long- lived. Since many ALPs may be produced in hot plasma in supernovae (SNe), a nearby
SNe Ia can be used as a probe of ALPs. It is desirable to predict the ALP emission from SNe Ia to discuss a possible
constraint that can be obtained from the event. ALPs may convert into photons and back in the magnetic field in the
intergalactic space and galaxies. It is hence possible to constrain the ALP parameters by γ-ray observations of a nearby
astronomical object which emits a lot of ALPs. Here, we calculate the ALP emission from type Ia SNe and take into the
account the light range of ALPs mass. Using the SN Ia model, we consider the issue of detection a photon flash from
SNe Ia.

Afternoon - 1 / 58

Exploring New Axion Parameter Space with The ORGAN Experiment: ORGAN-Q, ORGAN-LF, & Work Towards Phase 2

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We present recent developments from The Oscillating Resonant Group AxioN (ORGAN) Collaboration, focusing primarily on two experimental platforms beyond the main experiment - ORGAN-Q and ORGAN-Low Frequency (ORGAN-LF) - designed to expand axion parameter space coverage and test technologies for future searches.

ORGAN-Q is a pathfinding and testbed experiment targeting the range around ~25 μeV, which recently completed a science run with near-quantum limited sensitivity, and high frequency resolution. We report on its results and the future plans for ORGAN-Q, including upgrades and the performance of candidate technologies for Phase 2 of the main-line ORGAN Experiment.

ORGAN-LF, targeting the ~1 μeV range, is a new low-mass axion haloscope under development at Swinburne. Designed to operate within a large-bore MRI magnet, it utilises re-entrant cavity designs, and tests technology for future low mass searches. We outline the experimental plans, current build status, and projected sensitivity reach.

Finally, we provide an update on ORGAN Phase 2 R&D, with emphasis on high-frequency cavity innovations and readout. Together, these developments aim to extend the sensitivity of ORGAN across key regions of parameter space.

Monday / 59

Towards ultra-low backgrounds for high-efficiency transition edge sensors in optical and infrared axion searches

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Cryogenic transition edge sensors (TESs) are single photon detectors featuring high quantum efficiency and excellent energy resolution below 10% at optical and near-infrared wavelengths. If thermal backgrounds can be suppressed to sufficiently low levels, such detectors would be ideally suited for experiments searching for photon-axion conversion at these wavelengths such as light-shining-through-a-wall (LSW) experiments or axion interferometers. Here, we report on the determination of the system detection efficiency of the TES intended for a future run at the LSW experiment Any Light Particle Search II (ALPS II). With our latest experimental setup, we are able to achieve an SDE $gtrsim$ 80%. Furthermore, we report on a novel cold optical filter bench that could suppress backgrounds by more than two orders of magnitude. The filter bench can be remotely aligned and first results indicate a transmission of
$gtrsim$ 60%.

Morning - 6 / 60

Feasibility Study of Hidden Photon Dark Matter Searches with an Itinerant Single Microwave Photon Detector

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We present the design and simulation results of a superconducting quantum sensor aimed at the direct detection of axion and hidden photon dark matter in the microwave regime. These dark matter candidates are predicted to convert into microwave photons at very low event rates through their weak coupling to electromagnetic fields, posing a significant experimental challenge.
To overcome this, we aim to employ a QND-type itinerant single microwave photon detector, based on a superconducting qubit, designed for high detection efficiency and low dark count rates in the GHz range. We evaluate this architecture through detailed simulations of the circuit design and its expected performance. Furthermore, we investigate the functionality of key components under realistic cryogenic conditions to ensure efficient photon detection. These results lay the groundwork for our future experimental implementation.

Morning - 9 / 61

Search for Hidden Photon Dark Matter Using Direct Excitation of Superconducting Qubits

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We present a search for hidden photon dark matter using superconducting qubits, based on the method proposed by our group (Moroi et al., Phys. Rev. Lett. 131, 211001 (2023)). Hidden photon dark matter induces an AC electric field through the kinetic mixing with ordinary photons. This electric field can excite a qubit on resonance. Assuming that fake excitations are uniformly distributed in the frequency domain, a narrow dark matter signal can be detected by sweeping the frequency of tunable qubits. To determine the excitation rate at each frequency, we repeatedly let the qubit idle

for a fixed time and measure its state. In this presentation, we show the latest results of hidden photon searches by this detection method. Compared to the experiment reported last year [1], we have improved the qubit quality and optimized the resonator geometry, resulting in enhanced sensitivity. These results pave the way for comprehensive broadband searches and axion searches under strong magnetic fields.

[1] K. Watanabe et al., 2024, 19th Patras Workshop on Axions, WIMPs and WISPs (poster presentation, Patras, September 16–20).

Morning - 8 / 62

A Dark Photon Dark Matter Search with a Widely-Tunable SRF Cavity

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The SERAPH (SupERconducting Axion and Paraphoton Haloscope) experiment is a family of superconducting haloscopes being developed by the Superconducting Quantum Materials and Systems (SQMS) Center to search for wavelike dark matter. This presentation will focus on preliminary results from our dark photon dark matter search using a widely-tunable SRF cavity operating between 4-7 GHz, nicknamed the "plunger cavity."

I will present the cavity design and characterization, analyze the impact of microphonics on system performance and haloscope sensitivity, and describe our tuning methodology for this Q~10^8 cavity. The presentation will cover our haloscope analysis approach and discuss sensitivity limits achieved in this frequency range. Finally, I will outline lessons learned from this first search, implications for future axion searches, and proposed improvements for subsequent SERAPH experiments.

Afternoon - 2 / 63

Constraining Axions with Quantum Technology

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Axion-like particles (ALPs) are compelling dark matter candidates, particularly in the "ultralight mass regime." In this talk, I will discuss the theoretical framework for ALP interactions with Standard Model fields, emphasising the renormalization group (RG) running and low-energy matching in quantum field theory. Many quantum sensor experiments are designed to probe very light ALPs, which are especially sensitive to these effects due to large decay constants where running effects become significant. Furthermore, while linear axion interactions are dictated by their pseudoscalar nature, quadratic interactions resemble scalar interactions, leading to distinct experimental signatures. I will explore the discovery potential of various quantum technology-based experiments, including atomic clocks, interferometers, haloscopes, and fifth force searches. Finally, I will comment on the nonlinear behaviour of the ALP field near the Earth's surface and identify the classes of experiments that could be impacted by this feature.

Morning - 4 / 64

Towards a Cavity Haloscope with a GHz Tuning System Using Galvanically Contacted Transmon Qubits

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A critical challenge in cavity haloscope experiments is the development of fast and wide-range frequency tuning systems. One promising approach is to incorporate qubits based on DC SQUIDs into the cavity, where the qubit-cavity interaction is controlled by an external magnetic flux [1]. This non-mechanical method is particularly attractive for fast scanning, as it avoids the frictional heating that limits conventional tuning systems. Our previous work on the DarQ-Lamb experiment also demonstrated a search for dark photon dark matter using this tuning system with a tunable transmon qubit [2, 3]. However, in these previous studies, the frequency tuning ranges were limited to the order of 10 MHz [1, 2], primarily because the qubit-cavity interaction was not fully optimized for wide tuning.

This presentation discusses strategies to broaden the tuning range of such a cavity tuning system. This improvement is crucial for expanding the mass search range for dark matter. We report on the progress of a cavity haloscope with galvanically contacted transmon qubits. This approach is designed to achieve a strong qubit-cavity coupling regime, which is expected to enable a GHz-scale frequency tuning range.

[1] F. Zhao et al., (2025), arXiv: 2501.06882
[2] K. Nakazono et al., (2025), arXiv: 2505.15619
[3] K. Nakazono et al., (2024), 19th Patras Workshop on Axions, WIMPs and WISPs (Oral talk).

Morning - 4 / 65

Are axion-like particles required to explain the observations of very high-energy photons from GRB221009A?

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In 2022, GRB221009A was detected by the LHAASO collaboration as the brightest gamma-ray burst (GRB) ever recorded with photon energies that extended up to 18TeV. Combined with the redshift of $z = 0.151$ of the GRB, it has been questioned whether these observations can be reconciled

with standard physics, since such high energy photons suffer from absorption on the extragalactic background light (EBL). A possible explanation could be the oscillation between gamma rays and hypothetical axion-like particles (ALPs), which would effectively lower the absorption. Here, we analyze LHAASO data from GRB221009A using a maximum likelihood approach. We consider different magnetic-field scenarios for photon-ALP conversion and test different EBL models. We find that models including photon-ALP oscillations are not significantly preferred and we conclude that ALPs are generally not required to explain the LHAASO observations of GRB221009A. Instead, we are able to set competitive constraints on the photon-ALP coupling.

Morning - 9 / 66

DMRadio-GUT: quantum advantage at the GUT scale

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The DMRadio series of experiments is designed to probe pre-inflationary dark matter axions in the peV-neV range. Specifically, DMRadio-GUT is the ultimate DMRadio experiment with sensitivity to dark matter axions at DFSZ coupling in the 0.4-120 neV (100 kHz-30 MHz) range. To achieve this sensitivity to DFSZ axions at such low masses, new technologies are necessary to scan the desired parameter space within reasonable scan times. As a result, future experiments must employ novel magnet technologies, high Q resonators, and quantum devices with noise levels that have never been achieved before at these frequencies. In this talk we present requirements to achieve the required sensitivity, as well as first results from tests of high Q resonators and quantum amplifiers, namely radio frequency quantum upconverters (RQUs) which can achieve frequency-integrated sensitivity beyond the standard quantum limit. These results provide concrete paths forward in achieving the DMRadio-GUT requirements.

Morning - 4 / 67

Thermal Friction on Axion Domain Walls from Nonequilibrium Quantum Field Theory

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Cosmological models featuring QCD axions or axion-like particles (ALPs) can face a serious domain wall (DW) problem when the domain wall number N_{DW} , exceeds unity. While biased potentials are a commonly proposed solution, we explore alternative mechanisms based on thermal plasma friction.
Using techniques from nonequilibrium quantum field theory, we evaluate the quantum equations of motion governing the coupled dynamics of domain walls, free axions, and particles in the primordial Standard Model (SM) plasma. This framework enables us to calculate the thermal pressure exerted on a DW moving with velocity v, taking into account all relevant particle interactions and self-interactions that depend on the specifics of the axion model.
We further develop an extended Velocity-dependent One-Scale (VOS) model to describe the evolution of the DW network under the influence of friction. In this context, we also derive analytic

expressions for the energy loss due to both scalar radiation and the chopping mechanism and include friction terms arising from interactions with the Standard Model (SM) plasma.
Finally, we examine the implications of our model, establishing bounds and exploring Beyond Standard Model (BSM) signatures subject to these dynamics, such as constraints from Big Bang Nucleosynthesis (BBN), the Stochastic Gravitational Wave Background (SGWB), and CMB birefringence.

Morning - 1 / 68

Looking at Stars, Aiming for Axions

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Using stars as natural laboratories for fundamental physics is an idea with deep roots, but recent years have seen a dynamic resurgence in this approach. In this talk, we will explore how stellar observations - both historical and cutting-edge - are shedding light on axions and other feebly interacting particles. By tracing the evolution of these ideas, from classic arguments to modern developments, we aim to highlight the growing role of astrophysics in probing new physics.

Morning - 10 / 69

Tunable haloscope at 10 GHz probing up to KSVZ QCD axion models

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We report the QUAX haloscope improvements for the search of post-inflationary QCD axions at about 10 GHz frequency. With respect to previous QUAX results, a wide-tuning system is introduced and proved to work in a quasi-automatic protocol.

The haloscope resonator is a cylindrical copper cavity with a sapphire inner cylinder, which allows for a higher effective volume compared to an empty cavity resonating at the same frequency.
Through a clamshell-like mechanism, the cavity can be opened to change the frequency from 10.212 GHz to 10.154 GHz without significantly impacting the quality factor of its axion-sensitive TM030 mode.

The readout chain, using a traveling wave parameter amplifier as the first stage of amplification is devised to work near to the standard quantum limit. With the usage of an 8 T magnet, the haloscope

is able, in one hour of acquisition, to probe post-inflationary QCD axion models at $10^{-14}\,\mathrm{GeV}^{-1}$ level in the range $42 - 42.2\,\mu$eV.

With these improvements, QUAX paved the way for a tunable haloscope with QCD axion models' sensitivity in the $9 - 11$ GHz frequency range.

Morning - 6 / 70

Supernova bounds on new scalars from resonant and soft emission

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New light CP-even scalars arise in a variety of BSM scenarios aimed at solving the dark matter puzzle, generating neutrino masses and/or tackling the electroweak hierarchy problem. I will discuss supernova cooling constraints on new scalars that mix with the Higgs, couple only to nucleons, or couple only to leptons. In all these cases scalars with masses smaller than the plasma frequency in the supernova core are efficiently produced by resonant mixing with the in-medium longitudinal degree of freedom of the photon. The resulting bounds are free from uncertainties associated to the rate of emission of the scalar in nucleon-nucleon scatterings, which would otherwise badly affect the Higgs-mixed and nucleophilic scenarios.

Morning - 3 / 71

The ORGAN Experiment: Progress and Future Directions in High-Mass Axion Searches

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The Oscillating Resonant Group Axion (ORGAN) experiment is a microwave cavity haloscope searching for axion dark matter in the high-mass region of 15–50 GHz. The recently completed Phase 1b successfully scanned the 107.42–111.93 μeV (26–27 GHz) mass range using a novel rectangular copper cavity, achieving leading sensitivity and excluding axionlike particle (ALP) cogenesis models over this range. The rectangular geometry mitigates critical challenges associated with conventional cylindrical designs at high frequencies, including mode crowding, thermalization, and mechanical instabilities.

Looking ahead, ORGAN Phase 2 will substantially improve sensitivity across much of the Phase 1a parameter space (15–16 GHz) by operating at millikelvin temperatures with beyond-quantum-limited amplification. Further development includes the integration of single-photon detectors to reach sensitivity sufficient to probe the theoretically motivated KSVZ and DFSZ axion models. Parallel work is advancing kinetic inductance parametric amplifiers as part of this effort. Together, these upgrades position ORGAN to explore new parameter space in the high-mass axion regime with sensitivity approaching fundamental quantum limits.

Morning - 8 / 72

The Canfranc Axion Detection Experiment (CADEx): a novel haloscope search for Dark Matter axions in the mass range 330–460 μeV

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A range of haloscope searches are currently probing axions in the mass range ~2-40 μeV. However, simulations of the axion field in the early Universe are increasingly pointing towards heavier masses if we want the axion to comprise all of the Dark Matter in the Universe. I will briefly review these developments and then I will present The Canfranc Axion Detection Experiment (CADEx), a proposed haloscope search in the well-motivated but currently under-explored mass range 330-460 μeV. CADEx, to be installed at the Canfranc Underground Laboratory, will consist of an array of microwave resonant cavities in a static magnetic field, coupled to a highly sensitive detecting system based on Kinetic Inductance Detectors. I will present the timeline for CADEx as well as forecasts for its sensitivity to axions and dark photons.

Afternoon - 2 / 73

Updates on the Axion Longitudinal Plasma Haloscope (ALPHA) Phase I Construction

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The axion remains a compelling dark matter candidate, yet a substantial portion of its potential mass range remains unexplored. Post-inflation QCD axion string models suggest that axions could possess higher masses than what current haloscopes can detect. Traditional tunable cavity-based haloscopes have shown exceptional sensitivity at lower frequencies, but their effectiveness diminishes at higher frequencies due to reduced cavity volume. The Axion Longitudinal Plasma HAloscope (ALPHA) addresses these challenges by utilizing metamaterial resonators, which can operate between 10-100 GHz without volume constraints. This presentation will cover the progress of the initial phase of the ALPHA haloscope located at Yale, with a focus on the evolution of plasma resonator designs and the commissioning of the cryogenic receiver. The Yale installation features a cavity designed for the 10-20 GHz range, operated in a 9 Tesla magnetic field at millikelvin temperatures, with quantum-limited parametric amplifier readout. This phase of the ALPHA haloscope aims to both demonstrate enhanced sensitivity of metamaterial resonators within a high-field, large-bore magnet setting and establish KSVZ-limited constraints on the axion coupling for masses in the 40-80 μeV range.

Morning - 2 / 74

No Dark Matter Axion During Minimal Higgs Inflation

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In this talk, we will study minimal versions of Higgs inflation in the presence of a massless QCD axion. While the inflationary energy scale of the metric variant is too high to accommodate isocurvature bounds, it was argued that Palatini Higgs inflation could evade these constraints. We show, however, that an energy-dependent decay constant enhances isocurvature perturbations, implying

that axions can at most constitute a tiny fraction < 10−5 of dark matter. This conclusion can be avoided in EinsteinCartan gravity by an additional coupling of the axion to torsion, albeit for a very specific choice of parameters. Analogous constraints as well as the possibility to alleviate them are relevant for all inflationary models with a non-minimal coupling to gravity.

Afternoon - 4 / 75

New Physics searches at the NA62 experiment

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“The NA62 experiment at CERN is designed to measure the highly-suppressed decay K+ ⟶ π+ν¯
ν and has collected a large sample of K+ and π+ decays in flight during Run 1 (2016–2018) and Run 2 (since 2021). Searches for the decays K+ ⟶ π+X and π+ ⟶ e+N are presented using data collected in 2016–2022 and 2017–2024, respectively. No signal excess is observed and the results are interpreted to constrain a range of New Physics scenarios. Upper limits on the K+ ⟶ π+X branching ratio are established at the 10−11 level, providing constraints on dark photon, scalar and ALP couplings. From the search for heavy neutral lepton production in π+ ⟶ e+N decays of beam pions, upper limits of the extended neutrino mixing matrix element |Ue4|2 are established at the 10−8 level over the heavy neutral lepton mass range 95–126 MeV/c2
.”

Morning - 10 / 76

Looking for ultra-light axions using dwarf galaxies

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TBD

Afternoon - 2 / 77

Quantum Sensors for Dark Matter

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This talk will provide an overview of quantum sensing and its emerging applications in fundamental physics. In particular, it will highlight the use of qubits, the foundational units of quantum computing as novel sensors capable of detecting single quanta of energy beyond the reach of traditional dark matter detection methods.

Morning - 2 / 78

Dark photons, ALPs, and the microwave spectrum

Author: Bryce CYR[None]

Dark photons and axion like particles (ALPs) generically possess couplings to the standard model photon, which can give rise to unique spectral signatures that can be probed by ground- and space-based telescopes, such as the Tenerife Microwave Spectrometer (TMS), and the PIXIE/FOSSIL satellites. After a brief introduction to the theory of CMB spectral distortions, I will discuss how resonant conversions of visible light into dark photons or axions can lead to a measurable deviation of the CMB away from a perfect blackbody. This work builds upon previous results by including effects of entropy extraction on the distortion signature, which provides to a leading order correction to the dark photon constraints when considering pre-recombination conversions. I will also briefly highlight other work which has aimed at using a dark CMB to produce the radio synchrotron background anomaly, originally detected by the ARCADE-2 experiment and a direct scientific target for TMS.

Morning - 7 / 79

Dark Matter Axion Search with the HAYSTAC Experiment

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Astrophysical observations give overwhelming evidence for the existence of dark matter, and yet we know little about what they might be. Axion is a compelling candidate, as it also provides a solution to the strong CP problem in quantum chromodynamics (QCD) as proposed by Peccei & Quinn. I will present the results from the Haloscope at Yale Sensitive to Axion CDM (HAYSTAC) experiment, which scanned for axions between 17.28 –18.44 μeV and 18.71–19.46 μeV. No statistically significant evidence of an axion signal was observed, excluding couplings of |gγ|≥2.75×|gγKSVZ| and |gγ|≥2.96×|gγKSVZ| at the 90% confidence level over the respective regions. By combining this data with previously published results using HAYSTAC's squeezed state receiver, we have scanned a total of 2.27 μeV of parameter space between 16.96 –19.46 μeV, excluding | gγ |≥2.86×| gγKSVZ | at the 90% confidence level. These results demonstrate the squeezed state receiver's ability to probe axion models over a significant mass range while achieving a scan rate enhancement relative to a quantum-limited experiment.

Morning - 7 / 80

A High-Energy Neutrino Detection with KM3NeT

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The KM3NeT experiment, a next-generation neutrino observatory under construction in the depths of the Mediterranean Sea, aims to reveal the mysteries of the high-energy Universe by detecting neutrinos originating from astrophysical sources. In this talk, we present the observation of a high-energy neutrino event recorded by the KM3NeT detector, marking a significant milestone in its

scientific mission. The event, characterised by a well-reconstructed muon track and a deposited energy in the PeV range, stands out due to its high signal-to-noise ratio and angular resolution, making it a strong candidate for an astrophysical origin. This discovery not only demonstrates KM3NeT's capability to contribute to neutrino astronomy but also opens new opportunities for identifying cosmic accelerators and understanding the mechanisms behind the production of ultra-high-energy particles.

Afternoon - 6 / 81

Hunting axions with the James Webb Space Telescope

Author: Elena Pinetti[1]

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Axions with a mass around 1 eV can decay into near-infrared photons. Utilising blank-sky observations from the James Webb Space Telescope, I search for a narrow emission line due to decaying dark matter and derive leading constraints on the axion-photon coupling in the eV-scale mass range.

Afternoon - 3 / 82

TBD

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TBD

Morning - 4 / 83

Dark matter from the dark axion portal

Author: Paola Arias[None]

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In this talk, I will discuss dark matter production through the "pure dark axion portal", which describes the interaction between axions, photons, and dark photons. Under certain conditions, dark matter is produced via the freeze-in mechanism, leading to rich phenomenology. In particular, the heaviest particle in the dark sector decays into a lighter one and a photon. This model predicts a well-defined parameter space featuring a cold dark matter candidate that can be searched for. It also presents unique features that can be tested through cosmological and laboratory observations.

Morning - 10 / 84

SRG/eROSITA and the first uncontaminated view of the diffuse soft X-ray sky

Author: Konrad Dennerl[None]

"From December 2019 to February 2022, SRG/eROSITA has scanned the whole sky at 0.2-8 keV, with highest sensitivity in the soft (0.2-2.3 keV) X-ray band. Although designed primarily for cosmological studies, the eROSITA mission is also ideally suited for studying our immediate astronomical environment: the discovery of cometary X-ray emission has made us aware that we are observing the sky through regions of soft diffuse X-ray emission, powered by charge exchange between solar wind heavy ions and tenuous amounts of gas. Such gas in the Earth's exosphere creates an extended cloud of geocoronal X-ray emission, and interstellar gas streaming through the solar system causes the inner heliosphere to glow in soft X-rays. These foreground emission components have severely complicated the unambiguous interpretation of the diffuse soft X-ray sky to date. Now this situation has greatly improved: its wide field of view, high sensitivity to soft X-rays and high spectral resolution make eROSITA the perfect instrument for studying the diffuse soft X-ray sky, and observing from a distance of ~1.5 million km, eROSITA is unaffected by geocoronal X-rays. By having mapped the sky four times, starting at solar minimum, it becomes possible to isolate the heliospheric component. This allows us to obtain unprecedentedly detailed insights into the spatial, spectral, and temporal properties of the X-ray emission caused by the solar wind over a major part of the solar cycle, and to use it for mapping the flow of interstellar matter through the heliosphere. By subtracting the heliospheric component we can also reconstruct for the first time the sky as it would appear from outside the solar system. One immediate result is that, after removing all foreground components, even the darkest regions exhibit significant flux, providing solid evidence for the presence of a hot interstellar medium around the Sun on a scale of hundreds of parsecs. Given eROSITA's improved capacity to disentangle foreground components, its data could also enable more sensitive searches for faint features potentially linked to dark matter, such as the debated 3.5 keV line."

Morning - 6 / 85

Supernova limits on light dark sectors

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I will discuss recent progress on the understanding of the production of light dark matter in core-collapse supernova explosions. This leads to not only a constraint in the relevant parameter space due to cooling arguments of SN 1987A but also to a range of phenomenological consequences that can open new venues for detection. In particular, we will focus on the application to sub-GeV dark matter candidates

Afternoon - 2 / 87

Recent Progress on Axions in String Theory

Author: David Marsh[None]

The past few years have seen major advances in understanding the properties of axions in string theory. This progress is thanks to new computational tools that allow for fast and automated calculations with Calabi-Yau manifolds, which I will briefly describe. I will then describe the predictions string theory makes for axion masses, decay constants, and axion-photon couplings, and how these depend precisely on the topology of the Calabi-Yau. I will describe explicit constructions of fuzzy dark matter, and detailed calculations relating to decaying heavy axions, both of which seem to

point to a preference for low reheating temperatures in cosmology. Lastly, I will describe the correlation between QCD axion mass and topology, and how this makes it possible for axion haloscopes to experimentally test the string theory landscape.

Afternoon - 3 / 88

Current Status of the Axion Dark Matter eXperiment

Author: Dan Zhang[None]

The QCD axion is a compelling dark matter candidate for its natural emergence as a solution to the strong CP problem. Recent advancements in dilution refrigeration and quantum amplification technologies have enabled the Axion Dark Matter eXperiment (ADMX) to probe the well-motivated axion mass range for both benchmark models: Kim–Shifman–Vainshtein–Zakharov (KSVZ) and Dine–Fischler–Srednicki–Zhitnitsky (DFSZ). I will provide an overview of the current status of the main ADMX experiment, along with updates on related R&D efforts aimed at extending the search to higher-mass axions.

Afternoon - 4 / 89

First searches for axion and dark photon dark matter with MADMAX

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"The QCD axion is a well-motivated hypothetical particle that simultaneously addresses the strong CP problem and
constitutes a compelling cold dark matter candidate. The MADMAX experiment (Magnetized Disk and Mirror Axion
Experiment) is designed to search for axions in the mass range around 100 μeV by boosting the microwave radiation in induced by the inverse Primakoff effect in a dielectric haloscope. Recently, MADMAX has
achieved significant milestones, including the publication of its first search results for axion-like
particles and dark photons. The collaboration is now focused on preparations for the first cryogenic measurements
using a booster with adjustable disks for tuning. In this talk, an overview of the MADMAX experiment will be presented,
the recent results will be summarized and the upcoming steps toward a full-scale axion search will be outlined."

Morning - 8 / 90

Latest results from the LUX-ZEPLIN (LZ) dark matter experiment

Author: Emily Perry[1]

[1] *LBNL*

For the past two decades, dual-phase xenon time projection chambers (TPCs) have dominated the search for Weakly Interacting Massive Particles (WIMPs). Their scalability and advanced technology also grant them world-leading sensitivity to other Beyond Standard Model (BSM) physics and rare or exotic neutrino phenomena. The LUX-ZEPLIN (LZ) experiment, utilizing a 7-tonne liquid xenon target, is currently the largest and most sensitive of all TPCs. In this talk I will present the most recent search results from LZ.

Afternoon - 4 / 91

The hunt for high frequency gravitational waves —GravNet: a global network of HFGW detectors

Author: Kristof Schmieden[1]

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A new window to the universe was opened up with the detection of gravitational waves. While observations have been made at frequencies around hundreds of herz, and evidence was found at nHz frequencies, the high frequency region is still unexplored experimentally. To change this the GravNet initiative was founded with the aim to setup a global network of high frequency gravitational wave detectors.
The idea of searching for gravitational waves using radio frequency cavities immersed in strong magnetic fields has recently received significant attention. In particular, cavities with rather small volumes that are currently used to search for axion-like particles are discussed in this context. The first three detector of the GravNet network are under construction employing RF-cavities. Several sources of high frequency gravitational waves are discussed in new physics models, most prominently primordial black hole merges and axion super-radiance. Both production mechanisms lead to signals with distinct features. Challenges of detecting gravitational waves from both exemplary sources are discussed as well as prospects for the detection of GW using the network of RF cavity based detectors.

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La Laguna cultural visit

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Dinner

Morning - 6 / 94

Polarimetric Searches for Axions and High Frequency Gravitational Waves

Author: Laura Roberts[1]

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Physics beyond the standard model can be probed via the birefringence effects associated with axion dark matter backgrounds or a passing gravitational wave (GW). Exploiting the unified formalism between axion and high frequency GW effects, the use of optical cavities offer an opportunity for pre-existing experiments to adapt themselves to measure these polarization shifts. We demonstrate that with the ALPS II infrastructure there is the possibility to search for axion masses within the range ma ≈ 10−9 – 10−6eV. Additionally, with the proposed experimental design, the ALPS II optical cavities are capable of GW detection at frequencies above 100MHz to sensitivities on the order of 10−14Hz−1/2.
The use of birefringent mediums within the optical cavities such as quarter wave plates (QWP) to eliminate suppression of the antenna response in GW searches while improving the axion sensitivity is presented alongside the previous results. The goal of this work is to further contribute to the ongoing search for axion dark matter while contributing to the growing community in search of high frequency GW detection.

Morning - 8 / 95

Fine-grained dark matter substructure and axion haloscopes

Author: Giovanni Pierobon[None]

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The small-scale distribution of dark matter is expected to feature fine-grained substructure on solar-system scales, arising from the gravitational folding of an initially smooth phase-space sheet into many overlapping streams. For axions—especially in the post-inflationary scenario—early-Universe clustering can further amplify these densities. While such substructure is typically considered irrelevant for direct detection, it may significantly affect axion searches. We present several models of axion substructure and evaluate their impact on detectability. Our results show that high-frequency-resolution analyses can reveal these features, potentially enhancing axion discovery prospects even without reaching standard sensitivity thresholds.

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Registration

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Welcome

Afternoon - 3 / 98

From CAPP to DMAG

Author: Sungwoo Youn[None]

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Cavity haloscopes remain the most sensitive approach for searching for

axion dark matter, utilizing resonant microwave cavities in strong magnetic fields to detect axion-induced photons.

The Center for Axion and Precision Physics Research (CAPP) has established a world-class experimental facility to advance this technique in Korea.

Building on this foundation, the Dark Matter Axion Group (DMAG) continues and expands this legacy by leveraging cutting-edge technologies–including multiple magnet/cryogenic systems, high-Q tunable microwave resonators, and quantum-limited amplifiers such as JPAs.

With these capabilities, CAPP/DMAG is among the few programs capable of probing the theoretically favored axion-photon coupling parameter space.

This talk will present the current status of DMAG's haloscope experiments and outline future plans to accelerate the search for axion dark matter.

Afternoon - 5 / 99

Detection of light-mass and ultralight dark matter particles with the TESSERACT experiment

Author: Daniel McKinsey[None]

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Identifying dark matter particles remains a major goal in physics, with recent models suggesting masses below 1 GeV/c². The TESSERACT experiment will search for light and ultra-light dark matter using sub-eV threshold detectors, targeting masses down to 10 MeV via nuclear and electron recoils. It will combine multiple materials—superfluid helium, polar and scintillating crystals, and cryogenic silicon/germanium—for background rejection and recoil discrimination. Two shielded cryostats at the Laboratoire Souterrain de Modane will host the detectors, with underground operations starting in 2029. I will also present recent results from surface prototype tests.