T 70: Searches for Dark Matter II

Time: Wednesday 16:00–18:30 Location: Tt

T 70.1 Wed 16:00 Tt

The DARWIN full diameter test platform — •Florian Tönnies — Albert-Ludwigs-Universität Freiburg, Deutschland

In the last two decades liquid xenon TPCs have proven to be a very successful tool in the search for WIMP dark matter and other science channels. The detectors became bigger with every generation and the next generation and probably the final evolution stage of xenon TPCs for dark matter search will be DARWIN, which is planned to emply 50 tons of xenon. As it is almost twice the height and diameter of its direct predecessors currently under commissioning, its hardware components needs adequate testing at this new scale. For this purpose the DARWIN full-diameter test facility PANCAKE was developed and is being set up in Freiburg. We present it's unique features, design challenges, subsystems and first test results.

T 70.2 Wed 16:15 Tt

Modelling muon-induced background for the DARWIN observatory — •Jose Cuenca-García for the DARWIN-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT)

The goal of the DARWIN experiment is to become the most powerful WIMP dark matter (DM) detector using tens of tonnes of liquid Xenon as a target inside a sensitive time projection chamber. Although DM experiments are placed deep underground in order to be shielded from the cosmic radiation, muon-induced secondaries, especially neutrons are a relevant contribution to the background. These neutrons are produced by muons via direct spallation of nuclei or by the electromagnetic cascades generated when the muon passes through the rock, the shielding materials or the detector system itself. Since the energy of neutrons can be of the order of several GeV, they can deeply penetrate various materials before being stopped. The study of the muon-induced neutrons is therefore a key part for the design of the vetos around the detector. We present here detailed 3-dim full-chain Geant4 simulations of muons with their interactions producing the neutrons and other potential background sources for the DARWIN science program and estimate how much they can contribute to the total background of various physics channels.

T 70.3 Wed 16:30 Tt

A New Radon Emanation Chamber for the Radiopurity Assay of DARWIN — •Daniel Baur — University of Freiburg, Freiburg, Germany

Liquid xenon-based experiments are currently leading the search for WIMP dark matter. Their electronic recoil background in the energy region of interest is dominated by the naked (i.e. not accompanied by the coincident emission of a gamma-ray) beta decays of 214Pb, a progeny of 222Rn which is emanated from all material surfaces. Consequently, the assessment of 222Rn emanation is mandatory for the success of next-generation dark matter experiments with multi-ton xenon targets such as DARWIN. The 222Rn surface emanation can be measured directly with a radon emanation chamber, where the daughters of 222Rn are collected electrostatically on a silicon PIN diode and the subsequent alpha decays are detected. We report on a new suchlike detector for the radiopurity assay of DARWIN, currently being commissioned in Freiburg.

T 70.4 Wed 16:45 Tt

Towards a hermetic TPC for the DARWIN experiment — •Julia Dierle — Albert-Ludwigs-Universität, Freiburg, Germany

With its ambitious sensitivity to rare WIMP-nucleus interaction, the DARWIN experiment has to significantly exceed the already very low target-intrinsic background rates achieved by the currently leading dark matter experiments. These are dominated by radon which is constantly emanated from all detector surfaces. The concept of a hermetic TPC could complement approaches like radon distillation, material selection and surface treatment and contribute towards the goal of a radon-induced background rate of 0.1 μBq/kg. The hermetic TPC minimizes the surface being in direct contact with the active xenon target volume which must thus be enclosed in an almost liquid- and gas-tight shell. We report on the status and the first run of such a hermetic TPC prototype.

T 70.5 Wed 17:00 Tt

Optimizing Disk Positions for MADMAX — •Jacob Egge for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The **MA**gnetized **D**isk and **M**irror **A**xion e**X**periment is an upcoming dark matter experiment which will search for axions, a promising dark matter candidate. It relies on the conversion of axions from the galactic dark matter halo to detectable photons in a strong magnetic field. Dielectric disks placed inside the magnetic field each emit converted photons and boost the tenuous axion signal by coherent interference and resonances between disks. The spacing of disks determines this frequency-dependent boost and finding the optimal configuration for a given frequency range is a non-trivial task.

The position and orientation of up to 80 disks in the final full-scale experiment and 20 disks in the prototype experiment must be considered. As with any high-dimensional optimization, a brute force approach quickly becomes unpractical. This talk outlines a method that greatly reduces dimensionality and complexity of the problem by exploiting correlations between disk positions. This not only significantly speeds up optimization but also yields insights into the electromagnetic behavior of the disks.

Deviations from perfectly flat dielectric disks deteriorate the boost of the axion signal. First results on compensation by re-optimizing disk positions and subsequent relaxation of disk flatness requirements are presented as well.

T 70.6 Wed 17:15 Tt

Characterisation of dielectric materials for the MADMAX booster. — •Dominik Breitmoser for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The axion is a hypothetical low mass particle which is a prominent candidate for cold dark matter. The **MA**gentized **D**isc and **M**irror **A**xion e**X**periment is an experiment designed for its detection. MADMAX utilizes the axion photon conversion at dielectric surfaces in a strong magnetic field. Through constructive interference and resonance effects, the combination of several dielectric disks can boost the axion photon conversion sufficiently to make it detectable, requiring a material with high dielectric constant ε and low dielectric losses.

One of the favoured materials is Lanthanum Aluminate with $\varepsilon \approx 24$ available in small wafers. The MADMAX dielectric disks need to have a size of 1.25 m in diameter (0.3 m for the prototype). Thus, the disks need to be glued from hexagonal tiles using a cryo-compatible adhesive like Stycast Blue. Characterisation of these materials is performed by measurements with a Split-Post Dielectric Resonator in a cryostat at 10 GHz.

In this talk, this technique and its limitations are explained. Results of the dielectric loss and ε for these materials at several temperatures will be shown.

T 70.7 Wed 17:30 Tt

The MADMAX prototype booster system — •Christoph Krieger for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

The axion is a viable and natural candidate for (cold) dark matter. The theoretically favored mass range for the discovery of axions, 40 to 400 μeV, can be ivestigated using a dielectric haloscope. The **MA**gentized **D**isc and **M**irror **A**xion e**X**periment is based on this approach, utilizing the axion photon conversion at dielectric surfaces in a strong magnetic field. By combining many surfaces, the conversion can be boosted significantly using constructive interference and resonances.

To prototype the MADMAX booster system, a small booster with twenty dielectric discs of 300 mm diameter is foreseen. These discs have to be (re-)positioned in situ with micrometer precision inside a large magnetic field and a cryogenic environment. The prototype system will be commissioned in a dedicated cryostat at the University of Hamburg and later operated at CERN inside the MORPURGO magnet for a first axion search with a dielectric haloscope.

In this presentation, the concept of the MADMAX prototype and especially the development of the booster will be presented, showing the recent status of the production of tiled discs as well as studies on the first prototype of the drive system.

T 70.8 Wed 17:45 Tt

Investigation of dielectric loss (tanδ) of low-loss materials for the axion dark matter search experiment, MADMAX — •Erdem Oez for the MADMAX-Collaboration — RWTH, Aachen, Germany

In the presence of dark matter axions a dielectric material submerged in a magnetic field emits microwaves. The magnetized disk and mirror axion (MADMAX) experiment plans to use multiple (~ 80) large ($\sim$ 1 mm thick, $\sim$ 1.25 m diameter) dielectric disks to enhance the microwave signal. In order to further maximize generated signal, low-loss (tan$\delta < 10^{-4}$) materials such as Sapphire (Al2O3) or Lanthanum Aluminate (LaAlO3) need to be used as disk materials. In this talk we present a very sensitive resonator cavity method, measurements and results for investigation of dielectric properties of these materials.

T 70.9 Wed 18:00 Tt

Tuneable (HT)S RADES cavity prototype — •Jessica Golm for the RADES-Collaboration — European Organization for Nuclear Research (CERN), Geneva , Switzerland — Friedrich Schiller University Jena, Jena, Germany

The RADES (Relic Axion Detector Exploratory Setup) project has the goal of directly searching for axion dark matter above the 30 μeV scale employing custom-made microwave filters in magnetic fields, in particular exploiting existing accelerator dipole magnets. Our existing setup comprises an array of small microwave cavities connected by rectangular irises. The size of the unit cavity determines the main resonant frequency, while connecting a large number of cavities provides a large detection volume. The next step of the project is the development of superconducting cavities which resonate in the range of 8 to 9 GHz and have high quality factors in magnetic fields of up to 14 T. Suitable materials for this applications are high temperature superconductors (HTS) or Nb3Sn. A microwave cavity has been optimized to facilitate superconducting coating which fits in the bore of available high-field accelerator magnets at CERN. Such cavities can be used in multi-tesla magnetic fields and have a higher sensitivity compared to copper coated cavities of the same type. In addition, the new prototype is cut vertically along the electrical field lines which allows a tuning range of 600 MHz by adjusting the separation of the two halves. The present status of this program is described.

T 70.10 Wed 18:15 Tt

New method to search for axion-like particles demonstrated with polarized beam at the COSY storage ring — •Swathi Karanth for the JEDI-Collaboration — Marian Smoluchowski Institute of Physics, Jagiellonian University, Cracow, Poland

The axion was originally proposed to explain the small size of CP violation in quantum chromodynamics. If sufficiently abundant, it might be a candidate for dark-matter in the universe. Axions or axion-like particles (ALPs), when coupled with gluons, induce an oscillating Electric Dipole Moment (EDM) along the nucleon's spin direction. This can be used in an experiment to search for axions or ALPs using charged particles in a storage ring.

In spring of 2019, at the Cooler Synchrotron (COSY) in Jülich, we performed a first test experiment to search for ALPs using an in-plane polarized deuteron beam with a momentum of 0.97 GeV/c. At resonance between the spin precession frequency of deuterons and the EDM oscillation frequency there will be an accumulation of the polarization out of the ring plane. Since the axion frequency is unknown, the momentum of the beam was ramped to search for a vertical polarization jump that would occur when the resonance is crossed. At COSY, four beam bunches with different polarization directions were used to make sure that no resonance was missed because of the unknown relative phase between the polarization precession and the EDM oscillations. We scanned a frequency window of about a 1-kHz width around the spin precession frequency of 121 kHz. This talk will describe the experiment and show preliminary results.