T 105: Search for Dark Matter 6

Time: Thursday 16:15–18:45 Location: T-H37

T 105.1 Thu 16:15 T-H37

The MAgnetized Disk and Mirror Axion eXperiment — •Christoph Krieger for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

The axion is a viable and natural candidate for (cold) dark matter. The mass range for the discovery of axions, favored by some models, 40 to 400 μeV, can be investigated using a dielectric haloscope. The **MA**gentized **D**isc and **M**irror **A**xion e**X**periment is the first axion haloscope 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.

MADMAX will feature a booster system consisting of up to 80 dielectric discs with more than a meter diameter which can be precisely positioned at cryogenic conditions and inside a 9 T magnetic field created by a superconducting dipole magnet with a large warm bore. To prototype this challenging apparatus, a scaled down version (reduced number of discs with 300 mm diameter) is in development. It will be commissioned first at the Universität Hamburg in a dedicated cryostat. It is planned to conduct a first axion-like particle search utilizing the MORPURGO magnet at CERN.

In this presentation, the concept of MADMAX will be presented and an overview will be given on the status and development of MADMAX and its prototype.

T 105.2 Thu 16:30 T-H37

Measurements of dielectric properties of single crystals of Lanthanum Aluminate (LaAlO3) and Sapphire (Al2O3) for the axion dark matter search experiment, MADMAX — •Erdem Oez for the MADMAX-Collaboration — RWTH, Aachen

The magnetized disk and mirror axion (MADMAX) experiment will search for axions as cold dark matter candidate in the range of microwave frequencies from 10 to 100 GHz. Multiple parallel dielectric discs are planned to be used to boost the axion generated RF signal by 3 orders of magnitude compared to a single metal surface of the same area. Precise knowledge of the dielectric loss and the dielectric constant of the disc materials is crucial for understanding the predicted axion signal. At these RF frequencies the measurement of low loss materials are especially challenging. Here we present cryostatic measurements of LaAlO3 and Al2O3 which are the best candidate materials for MADMAX. The measurements were done in the 10 to 40 GHz range using a microwave resonator.

T 105.3 Thu 16:45 T-H37

Dielectric Disk Production for the MADMAX — •Dominik Breitmoser — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

The MAgentized Disk and Mirror Axion eXperiment (MADMAX) is an upcoming experiment to search for dark matter axions in the unexplored mass range of 40-400 μeV. The QCD axion is a solution to the strong CP problem and simultaneously an excellent cold dark matter candidate. In a strong magnetic field, axion-induced photons would be emitted at dielectric interfaces. MADMAX uses the dielectric haloscope approach to boost such a signal by combining up to 80 dielectric disks with 1.25 m diameter and precisely adjustment of the disk distances. The axion to photon conversion is enhanced through interference and resonance effects.

To reach the required sensitivity the disks need a large dielectric constant whilst having low dielectric losses. Experimental constraints demand a planarity below 10 μm, surface roughness below 10 μm and a thickness of 1 mm. A favorable material could be lanthanum aluminate. However the material is only available in the size of 3" wafers. Thus, the disks need to be produced from small tiles which are glued together. This talk presents the method of manufacturing a prototype disk (∅ 300 mm), the studies for optimizing production parameters, and explains the measurement system used for quality control.

T 105.4 Thu 17:00 T-H37

Calibrating a Dielectric Haloscope — •Jacob Egge for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee149, 22761 Hamburg

Dielectric haloscopes like the **MA**gnetized **D**isk and **M**irror **A**xion e**X**periment aim to detect axions, a dark matter candidate, from the galactic halo by resonant conversion to photons in a strong magnetic field. A movable stack of parallel dielectric disks can amplify the axion-photon conversion probability by several orders of magnitude. This amplification depends on the spatial variation of the axion, photon, and magnetic field. While the axion and magnetic fields are largely static and homogeneous, the frequency-dependent photon field inside the dielectric stack and thus the overall amplification is difficult to characterize.

In this talk, a new calibration method based on non-resonant perturbation theory is presented. It provides a promising way to experimentally constrain the photon field inside the dielectric stack. By perturbing the position of each dielectric disk and measuring the resulting change in reflectivity, one can infer the photon field configuration at each dielectric interface. This then allows computing the amplified axion-photon conversion probability independent of many parameters like dielectric loss and disk geometry. The validity and feasibility of this method are demonstrated with FEM simulations and first measurements on a 5 disks setup.

T 105.5 Thu 17:15 T-H37

Investigating a symmetric booster setup for MADMAX's dielectric haloscope — •Lolian Shtembari for the MADMAX-Collaboration — Max Planck Institute for Physics, Munich, Germany

The MADMAX experiment aims to directly detect galactic dark matter axions using the axion-induced emission of electromagnetic waves from boundaries between materials of different dielectric constants placed in a strong magnetic field. Carefully spacing many dielectric disks, their combined emission can be significantly enhanced (boosted) using constructive interference and resonances. In an attempt to reduce the complexity of the system and to gain an understanding of the flexibility and frequency response of the booster, we investigate the performance of a configuration made up of repeating symmetric sections of dielectric disks.

T 105.6 Thu 17:30 T-H37

Loss mechanisms of the MADMAX minimal booster setup — •Antonios Gardikiotis for the MADMAX-Collaboration — Institut für Experimentalphysik,Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

The axion is a promising candidate to solve the strong CP problem in the SM of particle physics. Its existence could also explain the observations in dark matter (DM) problem. To date, no axions have been detected. An envisioned technique for axion detection in the mass range of 40-400 μeV is the dielectric haloscope. The MADMAX (MAgentized Disc and Mirror Axion eXperiment) haloscope employs axion conversion into photons on surfaces within a strong magnetic field.

MADMAX uses a booster system consisting of multiple dielectric discs in front of a metal mirror to enhance the tiny axion converted power. Different booster setups have been built to examine the mechanical feasibility and electromagnetic behaviour. Project200 is a proof of principle setup with only one disc in front of a mirror. This simplified version of the MADMAX booster setup can compare basic radio frequency measurements with corresponding simulations.

In this presentation, the study of disc flatness, tilts of the disks and the antenna properties on a minimal setup that can help to better understand the loss mechanisms of the MADMAX booster setup will be discussed.

T 105.7 Thu 17:45 T-H37

Piezoelectric driven dielectric discs for the MADMAX haloscope — •Dagmar Kreikemeyer-Lorenzo for the MADMAX-Collaboration — Max Planck Institute for Physics, Munich, Germany

Axions are hypothetical particles conceived to explain the strong CP problem of the Standard Model. Simultaneously, axions are an excellent candidate for cold dark matter. MADMAX (MAgnetized Disk and Mirror Axion eXperiment) aims to detect axions in the mass range between 40 and 400 μeV. For that, it exploits axion to photon conversion at surfaces with different dielectric constants in the presence of a strong magnetic field. The MADMAX haloscope or booster setup will consist of several parallel and adjustable dielectric discs. The separation between discs will be optimised for the axion mass using very precise piezoelectric motors. Here we present the first investigation of the performance of such piezo motors, developed by the company JPE, under realistic conditions relevant for MADMAX. First results at room temperature and at 4.2 K will be shown.

T 105.8 Thu 18:00 T-H37

MADMAX: Dealing with Motor Failures — •David Leppla-Weber for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

The **MA**gnetized **D**isk and **M**irror **A**xion e**X**periment is a dielectric haloscope aiming to detect axions from the galactic halo by resonant conversion to photons in a strong magnetic field. It uses a stack of dielectric disks, called booster, that amplifies the axion-photon conversion probability over a significant mass range dependent on the position of the adjustable disks. In the planned prototype, depending on the axion mass, amplifications of a factor of $\sim 10^4$ can be achieved. The booster is positioned in a cryostat to achieve the low noise levels necessary for the detection of the tiny power stemming from the axion-photon conversion. In case a repair is needed, the cryostat has to be warmed up and cooled down again resulting in significant shutdown time of the experiment. To explore the case where one disk motor of the MADMAX prototype fails, an investigation for the maximum possible scan range with one disk stuck is presented. It is found that one stuck disk reduces the amplification by no more than 25 % over a range of 1.5 GHz. This enables the experiment to continue operating for a significant amount of time without having to interrupt the axion search and warm up the booster for repairs.

T 105.9 Thu 18:15 T-H37

A closed booster prototype for MADMAX: CB100 — •Chang Lee for the MADMAX-Collaboration — Max Planck Institute for Physics, Munich, Germany

CB-100 is a closed dielectric haloscope that aims to verify the dielectric haloscope concept. We use the setup to understand the reflectivity and thermal noise of a dielectric haloscope, which is a prerequisite for a good calibration. The MADMAX collaboration plans to use the system for its axion-like particle dark matter search using the MORPURGO magnet at CERN. We present the concept, design, and construction of CB-100. We also present the reflectivity measurement at room temperature and 4K.

T 105.10 Thu 18:30 T-H37

A novel approach to simulate axion-induced electrodynamics utilizing deep learning techniques in the MADMAX experiment — Dominik Bergermann, Tim Graulich, •Alexander Jung, Andrzej Novak, Ali Riahinia, and Alexander Schmidt — III. Physikalisches Institut A RWTH Aachen, Aachen, Deutschland

Promising concepts for the search for axion dark matter are dielectric haloscopes, such as the MAgnetized Disk and Mirror Axion eXperiment (MADMAX). The realisation of the experiment strongly depends on an accurate and reliable simulation leading to ever-increasing demands on computing resources, due to the complexity of simulations. A proof of principle is presented that modern deep learning techniques can be used in the simulation of the axion haloscope, and thereby assist in its optimisation.