T 77: Axion like particles II

Time: Thursday 16:30–18:50 Location: H-HS XV

Group Report T 77.1 Thu 16:30 H-HS XV

Any Light Particle Search II Overview and Status — •Richard C G Smith for the ALPS-Collaboration — DESY, Hamburg, Germany

The Any Light Particle Search II (ALPS II) is an experiment that will search for hypothesized axion-like particles using a light-shining-through-a-wall approach. These kinds of experiments generate axion-like particles from photons in a strong magnetic field, let the particles pass through a wall which blocks the photons, and then detect the photons regenerated from another strong magnetic field after the wall. The experiment is located at DESY in Hamburg which gives us access to infrastructure used in the HERA accelerator, such as tunnels, magnets, and cryogenics. In order to achieve the novel sensitivities planned we will use two 125 m long cavities housed in a vacuum system: one with 150 kW of circulating optical power to generate the axion-like particles, and one with a power build-up factor of 40,000 to resonantly enhance the probability of regeneration into photons. Both of these cavities will be located in a 5.3 T magnetic field provided by superconducting dipole magnets. ALPS II is currently being installed and we expect data collection to begin in 2021. This talk will provide the current status of the experiment, an explanation of the light-shining-through-a-wall concept, and a brief discussion of some of the technologies being used.

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Low Temperature MMC Detector Arrays for IAXO — •Daniel Unger, Andreas Abeln, Christian Enss, Andreas Fleischmann, Loredana Gastaldo, and Daniel Hengstler — Kirchhoff Institute for Physics, Heidelberg University

The International Axion Observatory (IAXO) is searching for evidence of axions or axion-like particles generated in the Sun. A large magnet inside a helioscope pointing towards the Sun is used to generate the required magnetic field to convert solar axions into photons via the Primakoff effect. The expected photon spectrum considering only axion-photon coupling has a black body shape with its maximum at around 4 keV. Hence, X-ray detectors with high efficiency and low intrinsic background are necessary. Low temperature detectors based on metallic magnetic calorimeters (MMCs) fulfill these requirements.

We present the characterization of the first MMC detector setup developed for IAXO. This system consists of a two dimensional 64 pixel MMC array covering a detection area of $16\,\mathrm{mm}^2$. Together with the SQUIDs necessary for the readout, the detector is mounted on a structure designed to be suitable for even larger MMC arrays. The performance of the detector array was investigated over a period of two months and will be discussed in terms of energy resolution, stability over time and background rate. To cope for different X-ray optics, a larger array covering an area of $1\,\mathrm{cm}^2$ is at present under development.

The results, in particular the achieved low intrinsic background, demonstrate that two dimensional MMC arrays are a promising technology for IAXO.

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Heterodyne Detection in ALPS II — •Todd Kozlowski for the ALPS-Collaboration — University of Florida

The Any Light Particle Search II (ALPS II) is a laboratory-based "light-shining-through-a-wall" experiment which aims to detect axion-like particles. This technique requires a detector that is sensitive to signals as weak as a single photon per 10 hours. One of two detection methods to be implemented in ALPS II uses heterodyne interferometry, whereby a strong local oscillator laser is overlapped with the weak signal field to generate a radio frequency optical beat note. Extremely weak signals can be resolved over sufficient time, thanks to the coherence between the signal and local oscillator fields. This coherence is maintained by a series of phase-locked-loops and a stable central optical breadboard, which minimizes relative phase noise between these fields. This talk will provide an overview of the heterodyne interferometry coherent detection technique, as well as its implementation in the ALPS II experiment.

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The TES Detector for ALPS II — •Rikhav Shah for the ALPS-Collaboration — JGU Mainz

The Any Light Particle Search II (ALPS II) is an experiment utilizing the concept of resonant enhancement to improve the sensitivity of traditional light shining through a wall style experiments. These experiments attempt to detect photons passing through an opaque wall via conversion to and from weakly interacting (relativistic) sub-eV particles, in the presence of a strong magnetic field. The detection of these photons requires a detector capable of observing the extremely small photon flux, of the order of $10^{-5}\,\mathrm{s}^{-1}$. To realize this, the detector must have a low dark count rate and high efficiency. This can be achieved with a transition edge sensor (TES). This is a cryogenic calorimeter which exploits the drastic dependence of a material's electrical resistance on the temperature, while at the superconducting edge. The current, updated setup of the TES at ALPS II will be presented. We discuss recent results from background studies of the TES, plans and challenges for the future as well as the current measurements from the detector in preparation for TES data taking starting in late 2021 or 2022.

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Developement of GridPix detectors for IAXO — •Tobias Schiffer, Klaus Desch, Markus Gruber, Jochen Kaminski, and Sebastian Schmidt — Physikalisches Institut, Universität Bonn

In the scope of the search for axions and axion like particles (Alps) with helioscopes, like the International Axion Obeservatory (IAXO) and its precurser BabyIAXO, detectors capable of measuring low energy X-rays down to the 200 eV range are necessary. For this purpose the GridPix detector is an appropriate solution, which has already been used successfully at CAST.

The GridPix is a MicroMegas like readout consisting of a pixelized readout ASIC (Timepix/Timepix3) with a perfectly aligned gas amplification stage, which is photolithographically built on top of the ASIC. Resulting in a very high granularity this detector is capable of detecting single electrons allowing the measurement of low energy X-rays. To convert these X-rays into electrons a small gas volume is built above the readout sealed with an X-ray entrance window.

For the goals of IAXO very low backgrounds need to be achived with the detectors and therefore only a few radiopure materials are contemplable. Also, to get a good signal to noise ratio the X-ray entrance window needs to be as transparent as possible for the low energy X-rays, while still maintaining a barrier between the detector gas and the vacuum system in front. This is achived with an ultra thin silicon nitride membrane.

This talk will present the challenges of the design process and the current status of the detector.

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A low-background Silicon Drift Detector system for axion research with IAXO — •Thibaut Houdy[1,2] and Susanne Mertens[1,2] — [1]Max-Planck-Institut für Physik, Föhringer Ring 6, D-80805 München, Germany — [2]Physik-Department, Technische Universität München, D-85747 Garching, Germany

The nature of dark matter is among the most challenging question of modern physics. Axions are invoked to solve the strong CP problem and are dark matter candidates. IAXO is the new generation helioscope, designed to discover solar axions by measuring x-rays induced by axion-photon conversion. The requirement for the detector to reach an extremely low background level below 10 keV is very challenging.

The TRISTAN project is developing a new detection system using silicon drift detector (SDD) for upgrading the KATRIN experiment and search for keV sterile neutrino. We propose to use this unique technology as an x-ray detector for the IAXO experiment. A first prototype detector revealed excellent spectroscopic quality, matching each IAXO requirements however the required background level remains to be demonstrated.

A dedicated test-bench is now being built to assess the detector background. This includes simulations of the external background, design of the shields, determination of the natural radioactivity of detector board and front-end electronics. In this talk, first results of measurements in the Munich shallow underground laboratory will be reported. Secondly, conceptual design studies of the final detector system, meeting the required background level, will be presented.

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Preliminary results of a GridPix based IAXO prototype de-

tector — •Sebastian Schmidt, Klaus Desch, Jochen Kaminski, Tobias Schiffer, and Johanna von Oy — Physikalisches Institut der Universität Bonn

The International AXion Observatory (IAXO) is a next generation axion helioscope aiming for an order of magnitude improvement on the axion photon coupling $g_{a\gamma}$ over the current best results by the CERN Axion Solar Telescope (CAST). Such helioscopes utilize the inverse Primakoff effect to reconvert solar axions (and potential other ALPs) into X-rays in their respective magnetic fields.

A gaseous detector based on 7 GridPixes, a combination of a 256 × 256 pixel Timepix ASIC and an integrated MicroMegas stage on top, together with veto scintillators and an FADC, were deployed at CAST in 2017/18 to develop an ultra low background detector for IAXO.

This talk will present preliminary results of the data taking campaign from 2017/18 and compare it with the current best limit on the axion electron coupling g_{ae}. The focus will be the improvements given by each of the detector features and the importance of ray tracing the axion / X-ray paths from the Sun to the detector.

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Large x-ray detector design for Baby-IAXO — •Andreas Abeln, Daniel Unger, Daniel Hengstler, Loredana Gastaldo, Christian Enss, and Andreas Fleischmann — Kirchhoff-Institute for Physics, Heidelberg University

Axions are promising candidates for cold Dark Matter as well as for solving the strong CP problem, their detection could shine light onto two important open questions in particle physics. The International AXion Observatory (IAXO) is an experiment designed for the validation of the existence of axion or axion-like particles (ALPs) produced in the Sun. IAXO is a fourth generation helioscope and will consist of a 20 m long magnet with field up to 6 T filling eight bores with diameter 60 cm. In this volume axion can be converted back to photons. Solar axions would produce a black body spectrum picking between 4 keV and 6 keV. The photons produced in the conversion volume are then focused onto high resolution and low background x-ray detectors. Metallic magnetic calorimeters (MMCs) have shown extremely good energy resolution and mainly unit quantum efficiency in the energy range of interest. First investigations have shown the possibility to reach very low level of undesired events.

We present the development of a new 2D MMC array characterized by 64 pixels covering an active surface of 1 cm^2. This absorber area perfectly contains the focal area of the x-ray optics foreseen to be used in Baby-IAXO, an intermediate stage of IAXO. The pixels are optimized to have high efficiency up to 10 keV. The expected energy resolution is 12 eV FWHM. We discuss the chip design and expected performance.

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Cryogenic Setup for the Operation of Metallic Magnetic Calorimeters in BabyIAXO — •D. Hengstler[1], A. Abeln[1], D. Unger[1], U. Schneekloth[2], A. Fleischmann[1], L. Gastaldo[1], and C. Enss[1] — [1]KIP, Heidelberg University — [2]DESY

The International Axion Observatory (IAXO) aims for the detection of solar axions. This helioscope will feature a 20 m long magnet pointing to the Sun with a magnetic field of up to 6 T in which axions could be converted to X-rays. An X-ray optics will focus the X-rays produced in a bore of 60 cm diameter to a detector positioned in the focal plane.

Towards IAXO a smaller version of the helioscope will be developed to fix the technologies for the final experiment. This project goes under the name babyIAXO and will be located at DESY, Hamburg. For babyIAXO, we propose to use metallic magnetic micro-calorimeters as alternative X-ray detectors. This type of energy-dispersive particle detectors has not only been shown to achieve excellent energy resolutions down to 1,6 eV at 6 keV but also provides a quantum efficiency up to 100 % and a low background level, both being essential for rare-event searches. To reach the necessary operating temperatures of around 20 mK, magnetic micro-calorimeters are typically operated in a dry, pulse-tube cooled ^{3}He/^{4}He dilution refrigerator.

We discuss the technological challenges that arise from mounting the cryogenic setup at the helioscope and suggest possible solutions to them. In particular, we present a study for operating a dry dilution refrigerator that is tilted with respect to the gravitational field axis and experiences vibrations due to the tracking of the Sun.