2nd Workshop on Microwave Cavities and Detectors for Axion Research

Tuesday, January 10, 2017 - Friday, January 13, 2017

Lawrence Livermore National Laboratory

Book of Abstracts

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First results from a microwave cavity axion search at 24 µeV

Author: Benjamin Brubaker[1]

[1] *Yale University*

Corresponding Author: benjamin.brubaker@yale.edu

I will report on the first results from a new search for axion dark matter using a microwave cavity detector at ~5 GHz frequencies. This detector has achieved near-quantum-limited sensitivity using a dilution refrigerator and Josephson parametric amplifier, and excluded axion-photon-photon couplings a factor of 2.3 above the benchmark KSVZ model in the mass range 23.55 µeV< m <24.0 µeV. These are the first limits within the QCD axion model band in the mass decade above 10 µeV.

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Active circuits for resonant axion detectors

Author: Ian Bailey[1]

Co-author: Edward Daw [2]

[1] *Lancaster University / Cockcroft Institute of Accelerator Science and Technology*

[2] *The University of Sheffield*

Corresponding Author: e.daw@sheffield.ac.uk

The key difficulty taking cavity axion detectors forward is the rate of coverage of possible axion masses. With metal cavity boundary conditions determining the modal frequencies, you are limited to the physical modes of the cavity having a high form factor. We examine whether artificial modes generated by feedback through high Q resonant filters outside the cavity could form artificial high-Q modes. Running many of these filters in parallel could generate a picket fence of modes, which might for some configurations allow one to multiply the search rate by the number of these artificial modes. We examine the practicalities of implementing these external resonators including their noise contribution and the question of their behaviour in the quantum limit.

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Novel materials for dispersion engineering in an accelerator environment

Author: Emmy Sharples[1]

[1] *Helmholtz Zentrum Berlin*

Corresponding Author: emmy.sharples@helmholtz-berlin.de

This talk provides an introduction to novel materials for dispersion engineering in an accelerator environment. The focus will me on metamaterials, the unique effects they give rise to and how these can provide interesting responses in accelerators. An overview of existing metamaterials schemes for accelerator applications will be presented, including an in depth discussion on the CSRR (complementary split ring resonator) loaded waveguide for reverse Cherenkov applications. The challenges these materials pose in the accelerator environment will be discussed and methods to mitigate these effects proposed. In addition to metamaterials, wavelength scale dispersion engineering will be discussed in cases where the length scales of metamaterials are unsuitable. Finally, new plasmonic

materials, such as transparent conducting oxides and intermetallics with be discussed and their integration into both metamaterial and dispersion engineering will be explored.

Summary:

The talk plans to cover; an introduction to metamaterials, the basic principles, unique effects they give rise to, common metamaterial forms and interesting applications. Then it will move on to metamaterials in accelerators, looking at the challenges they pose, existing schemes and their drawbacks. I will then talk briefly on my own project of the CSRR loaded waveguide, the design considerations made, the electromagnetic analysis, the wakefield analysis and the particle in cell response. Wavelength scale dispersion engineering will then be discussed focusing on how this is differs from metamaterials, and why this is a better choice for certain applications and environments. Finally I will provide an introduction to new plasmonic materials, and discuss their applications in both metamaterials and dispersion engineering.

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Novel Resonant Cavity Designs and Applications to Axion Haloscopes

Author: Michael Tobar[1]

[1] *University of Western Australia*

Corresponding Author: michael.tobar@uwa.edu.au

At the University of Western Australia we are investigating novel resonant cavity structures for a variety of applications ranging from tests of fundamental physics, quantum information techniques and applied technologies. After a short introduction, this presentation will focus on our work in designing novel cavities geometries for axion detection. First we will discuss our work on using 3D lumped "re-entrant" cavities, which offer high tuning ranges at cryogenic temperatures [1], for the potential application for detection of low mass axions between the range of 50 neV to 1 μev [2]. Secondly, we will discuss work on using multiple post cavities [3-5] and how they may aid in designing high frequency haloscopes. Thirdly, we will present our experimental and theoretical work on higher order reentrant post modes, and discuss their sensitivity to axions as well as implications for cavities with tuning posts and gaps between the post and cavity end wall [6]. Finally we will discuss our work on dielectric cavities, 3D printed superconducting cavities [7] and some new designs for high frequency axion haloscopes.

[1] NC Carvalho, Y Fan, ME Tobar, "Piezoelectric tunable microwave superconducting cavity", Rev. Sci. Instrum., vol. 87, 094702, 2016.
[2] BT McAllister, SR Parker, ME Tobar, "3D lumped LC resonators as low mass axion haloscopes", Phys. Rev. D 94, 042001, 2016.
[3] M Goryachev, ME Tobar, "Reconfigurable microwave photonic topological insulator," accepted to be published in Phys. Rev. Applied, Nov. 2016. arXiv:1606.02001[physics.ins-det].
[4] M Goryachev, ME Tobar, Creating Tuneable Microwave Media from a 2D Lattice of Re-entrant Posts, Journal of Applied Physics, vol. 118, 204504, 2015.
[5] M Goryachev, ME Tobar, "The 3D split-ring cavity lattice: a new metastructure for engineering arrays of coupled microwave harmonic oscillators," New J. Phys. 17, 023003, 2015.
[6] BT McAllister, Y Shen, SR Parker, ME. Tobar, "Higher Order Reentrant Post Modes in Cylindrical Cavities," arXiv:1611.08939[physics.ins-det].
[7] DL Creedon, M Goryachev, N Kostylev, T Sercombe, ME Tobar, A 3D Printed Superconducting Aluminium Microwave Cavity, Appl. Phys. Lett. vol. 109 , 032601, 2016.

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Analysis of a Corrugated Coaxial Waveguide Resonator for Mode Rarefaction in a Gyrotron

Author: Kalpana Singh[1]

[1] *University of Alberta*

Corresponding Author: kalpana.singh@ualberta.ca

—Canceled Talk—
In the development of high-power, high-frequency gyrotrons, two major constraints are the thermal loading of the wall of the waveguide resonator and the potential depression inhibiting the transport of large electron beam currents. The introduction of a coaxial metal insert in a circular waveguide resonator reduces the potential depression caused by the presence of the electron beam, and thus a coaxial waveguide transports a higher vacuum limiting current than a circular waveguide (without such a coaxial insert). The enhanced current transport capability of a gyrotron using a coaxial waveguide increases the electron beam power available in the device for conversion to microwaves. An unfolding method of selecting the desired mode amongst the competing nearby modes in a coaxial cavity interaction structure by tapering the structure cross section will be presented.

Summary:

The analysis of a coaxial waveguide resonator with its central conductor corrugated with wedge-shaped slots, considering space harmonic effects due to slot periodicity can be used to study the problem of mode competition in a gyrotron. A more positive slope of the plot of the eigenvalue versus the ratio of the waveguide wall to outer slot radii (coaxial parameter) for the desired mode, typically, TE8,4 as compared to the corresponding slopes for the competing modes formed a basis for the study of mode separation. Considering the aspect of mode separation on the basis of the relative slopes of the eigenvalue plot and that of mode degeneracy, a tradeoff was made to select the slot depth at a value intermediate between the values corresponding to the narrow and deeper slots. For the slot depth parameter selected, one may find the coaxial parameter, around which to taper the structure cross section, for mode separation on the basis of relative slopes of the eigenvalue plot, avoiding, at the same time, the region of the mode degeneracy. The analysis and interpretation of results for mode separation with reference to the typical mode TE8,4 chosen is extendible to higher modes as well.

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Overview of SRF Cavity R&D at Jefferson Lab

Author: Larry Phillips[1]

Co-author: Matthew Burton [2]

[1] *Jefferson National Lab*

[2] *William and Mary, and JLAB*

Corresponding Author: phillips@jlab.org

A brief description of SRF cavity R&D activities at JLAB will be presented.
For several decades, Jefferson Lab has been engaged in small sample studies of superconducting film properties using deposition by energetic ion condensation.
Recently a program has been launched using this technique to energetically deposit films on copper cavity substrates for accelerator application, which will be discussed.

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Multiple-cavity detector for axion search

Author: SungWoo YOUN[1]

[1] *CAPP/IBS*

Corresponding Author: swyoun@ibs.re.kr

Exploring higher frequency regions in axion dark matter searches using microwave cavity detectors requires a smaller size of the cavity as the TM010 frequency scales inversely with the cavity radius. One of the intuitive ways to make a maximal use of a given magnet volume, and thereby to increase the experimental sensitivity, is to bundle multiple cavities together and combine their individual outputs ensuring phase-matching of the coherent axion signal. The Experiment of Axion Search aT CAPP (EAST-C) is a dedicated project to develop multiple-cavity systems at the Centre for Axion and Precision Physics Research (CAPP) of the Institute for Basic Science (IBS). The conceptual design of the phase-matching mechanism and experimental feasibility using a double-cavity system will be presented in this talk.

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Axion Haloscopes with Toroidal Geometry

Author: Harry Themann[1]

[1] *Center for Axion and Precision Physics*

Corresponding Author: themann@ibs.re.kr

The axion power in a resonant cavity is proportional to B^2V. The radius of cylindrical cavity decreases linearly with increasing frequency thus decreasing the volume as the square of the frequency increase. Attempting to recover the volume, and thus a reasonable axion power, one can increase the length of the cavity. This quickly leads to mode crossings and potential mode localizations due to fabrication errors. To address these issues we have decided to explore a toroidal geometry for an axion haloscope. The toroid dispenses with endcaps so the primary B field does not encounter any perpendicular surfaces, making it an attractive design for superconducting film application. In our first phase of R&D we have designed and fabricated a small, 140mm diameter, toroid and explored its resonant behavior with and without a tuning system. We have also installed a toroidal solenoid and taken data in the 25-33 μeV range. I will present our experiences with our "Cappuccino Sub" and some future plans.

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The Electric Tiger Experiment: a Proof-of-Concept for the Periodic Dielectric Loaded Resonator

Author: Benjamin Phillips[1]

[1] *University of Washington*

Corresponding Author: bejphil@uw.edu

The Electric Tiger experiment is a resonant cavity for the detection of axions in the 4-5 GHz range. The cavity uses a first-of-its-kind detection method – dielectric media placed at regularly spaced intervals within the cavity. Such a search method allows for the construction of a simple tuning mechanism and a wide range of frequencies that can be searched with a single cavity. The tuning and mode identifications/tracking techniques developed by this experiment are translatable to open resonator axion searches that are suitable for very high frequency ranges (> 10 GHz).

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ABRACADABRA: A broadband/resonant search for axions

Author: Yonatan Kahn[1]

[1] *Princeton University*

Corresponding Author: ykahn@princeton.edu

In the long-wavelength regime, axion interactions with a static magnetic field can be described in terms of an effective current which sources a small oscillating magnetic field. I will describe a new experiment (ABRACADABRA) to detect this axion effective current which can operate with either broadband or resonant readout of the signal. Inspired by advances in medical physics and precision magnetometry, the broadband approach has advantages at low axion mass and can probe many decades of mass simultaneously. The combination of broadband and resonant approaches potentially has sensitivity to GUT-scale QCD axions. I will discuss recent progress on a prototype of ABRACADABRA under development at MIT.

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Ansys HFSS Tutorial

Author: Mark Jones[1]

[1] *Pacific Northwest National Laboratory*

Corresponding Author: a.mark.jones@pnnl.gov

This informal session will provide an introductory tutorial on the use of Ansys High Frequency Structure Simulator (HFSS) with a live demonstration of example models. Specific features relevant to achieving accurate cavity and antenna simulation results will be highlighted.

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PBG cavities for future ADMX

Author: Nathan Woollett[1]

[1] *LLNL*

Corresponding Author: woollett2@llnl.gov

As ADMX is looking towards higher frequencies, the reasons to use conventional microwave cavities over other technologies becomes less clear cut. In this talk I will discuss ideas using photonic bandgap structures and meta materials in conjunction with microwave cavities; the benefits which they present and the challenges they pose.

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CULTASK: The first axion search experiment in Korea

Author: Ohjoon Kwon[1]

Co-authors: Doyu Lee [2]; Jinsu Kim [2]; Soohyung Lee [1]; Woohyun Chung [1]

[1] *Center for axion and precision physics research @ Institute for Basic Science*

[2] *Department of Physics, Korea Advanced Institute of Science and Technology(KAIST)*

Corresponding Author: o1tough@ibs.re.kr

CAPP's axion searching experiment named as CULTASK (CAPP's Ultra Low Temperature Axion Search in Korea) adopts P. Sikivies's axion haloscope that uses strong magnetic field applied high Q factor of microwave cavity. We have started the first CULTASK experiment at 10.3μeV mass region and we demonstrate the progress and prospect. The dilution refrigerator (Bluefors LD 400 series) with 8T superconducting magnet is fully equipped and it successfully cools the cavity down to 30mK or less even with all the heavy supporting jigs and electronic components such as piezo actuators. We especially use vertically split cavity that promises to solve contact problem of TM010 mode in cylindrical cavity. The resonance frequency is tunable within 2.1GHz to 2.5GHz by perturbing the field with high permeability of dielectric rod; (CULTASK uses 99.99% sapphire), which is driven by a rotational piezo. The unloaded Q factor measurement is more than 50,000 when the cavity is in cryogenic condition. SQUID amplifier test results will be shown either, which would be used in next run.

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Hybrid cavities for axion detectors

Author: David Tanner[1]

Co-author: Ian Stern [1]

[1] *University of Florida*

Corresponding Author: tanner@phys.ufl.edu

Hybrid cavities, cavities with a layer of superconductor applied on top of the OFHC copper cavity walls, are studied. The goal is to improve the quality factor (Q) of the resonator. The superconductor must have its surface parallel to the external field and must be thinner than the penetration depth and comparable in thickness to the fluxoid spacing in the type II superconductor at the 8 T operating field. Q for a single thin layer and of a multilayer superconductor/ insulator stack applied directly to the copper are estimated. The results for these thin-film coatings are not good. However, if a layer or a multilayer stack of the superconductor were separated from the copper by a thick insulating spacer, one that is about a quarter wavelength at the cavity resonant frequency, extremely high Q factors could be obtained. Even when the contribution of the normal metal ends (where the external field is perpendicular to the surface) is included, the Q is improved compared to an all-metal cavity.

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Pound – Drever – Hall frequency locking method

Authors: David Tanner[1]; Neil Sullivan[1]; Shriram Sadashivajois[1]

[1] *University of Florida*

Corresponding Author: ramjois@ufl.edu

We use the Pound reflection locking method to tune the cavity. We input a phase-modulated RF signal to the cavity through a directional coupler. The RF signal reflected by the cavity is given to a lock in amplifier using a Zero bias Schottky detector. The output of the lock in amplifier gives a measure of how far the carrier is off the resonance. This output is fed to an integrator and the signal can be used as a feedback signal to tune the cavity using a servo control.

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Progress on the ARIADNE axion experiment

Author: Andrew Geraci[1]

[1] *University of Nevada Reno*

ARIADNE is a collaborative effort to search for the QCD axion using techniques based on nuclear magnetic resonance. In the experiment, axions or axion-like particles would mediate short-range spin-dependent interactions between a laser-polarized 3He gas and a rotating (unpolarized) tungsten attractor, acting as a tiny, fictitious "magnetic field". The experiment has the potential to probe deep within the theoretically interesting regime for the QCD axion in the mass range of 0.1-10 meV, while being independent of cosmological assumptions. The experiment relies on a stable rotary mechanism and superconducting magnetic shielding, required to screen the 3He sample from ordinary magnetic noise. Progress on testing the stability of the rotary mechanism will be reported, and the design for the superconducting shielding in the experiment will be discussed.

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Welcome & Overview

Author: Gianpaolo Carosi[1]

[1] *Lawrence Livermore National Laboratory*

Corresponding Author: carosi2@llnl.gov

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Author: Gianpaolo Carosi[1]

[1] *Lawrence Livermore National Laboratory*

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Author: Gianpaolo Carosi[1]

[1] *Lawrence Livermore National Laboratory*

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Corresponding Author: daleli@slac.stanford.edu

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Corresponding Author: seaning@berkeley.edu

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Corresponding Author: avdixit@uchicago.edu

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Corresponding Author: sonnenschein@fnal.gov

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UFL R&D Work

Corresponding Author: ianstern@aol.com

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Simulation of Superconducting QUBIT devices

Corresponding Author: materise1@llnl.gov

Superconducting qubits have matured from platforms demonstrating and manipulating macroscopic coherent quantum states to realizing exotic quantum states, running surface error correction codes, and single photon detection to name a few recent milestones. This talk will review the fundamentals of circuit QED related to the design and simulation of superconducting qubits. A brief overview of how to simulate the classical components of these devices using the
finite element multiphysics software, COMSOL, will follow the discussion of their equivalent circuit models.

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Corresponding Author: i.bailey@lancaster.ac.uk

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New ideas in cavity geometries and materials

Corresponding Author: moretti@fnal.gov

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Searching for Low Mass Axions with an LC Circuit

Author: Nicole Crisosto[1]

Co-authors: David Tanner [2]; Pierre Sikivie [2]; Sullivan Neil [2]

[1] *University of Florida ADMX*

[2] *University of Florida*

Corresponding Author: tanner@phys.ufl.edu

Axions are a promising cold dark matter candidate. Using the conversion of axions to photons in the presence of a magnetic field haloscopes can be employed to detect axions as is done in microwave cavity searches such as ADMX. To search for lighter, low frequency axions in the unexplored sub 100 neV (50 MHz) range a tunable LC circuit has been proposed. Progress in the development of such an LC circuit based search will be presented. This will include preliminary results from prototypes using electrical tuning, superconducting inductive loops, and aluminum shielding.

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The ORGAN Experiment

Author: Ben McAllister[1]

Co-authors: Eugene Ivanov [2]; Michael Tobar [2]

[1] *ARC Centre of Excellence for Engineered Quantum Systems, School of Physics, University of Western Australia*

[2] *The University of Western Australia*

Corresponding Author: ben.mcallister@uwa.edu.au

The Frequency and Quantum Metrology Laboratory at UWA is in the process of constructing a haloscope (the Oscillating Resonant Group Axion converter, or ORGAN) designed initially to search for axions around 110 micro-eV, or 26.6 GHz, with the ultimate goal of performing a wide range search above 20 GHz. The primary motivation for this search is a direct test of the Beck result [1], which claims a potential signal due to an axion resonance effect in Josephson Junctions. The proposed signal suggests axions at 26.6 GHz +/- ~500 MHz. The search will consist of several phases, and the initial pathfinding run is currently underway. The pathfinding search consists of a single copper resonant cavity embedded in a 7 T magnetic field at 4 K, employing a traditional HEMT based amplifier and readout via a high-speed digitizer, the detecting mode was chosen to be a TM¬020 mode [2]. We discuss the preparations for this search, as well as the planned future phases and extensions, which includes first results at cryogenic temperatures. We are exploring different mechanisms of cavity tuning, as well as different methods for the power combining and synchronisation of multiple cavities, a common theme in high frequency axion searches. We will discuss novel cross-correlation measurement schemes, which are two channel measurements where signals common between channels are preserved, whilst noise uncommon between channels is rejected. We propose a way to utilize these techniques in multiple cavity axion searches [3].

[1] C. Beck, Phys. Rev. Lett. 111, 231801 (2013) doi:10.1103/PhysRevLett.111.231801 [arXiv:1309.3790 [hep-ph]].

[2] B. T. McAllister, S. R. Parker, E. N. Ivanov, and M. E. Tobar, Proceedings of the 12th Patras Workshop on Axions, WIMPs and WISPs [arXiv:1611.08082 [hep-ex]].

[3] S. R. Parker, B. McAllister, E. N. Ivanov and M. E. Tobar, arXiv:1510.05775 [physics.ins-det]. (update forthcoming)

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The Cosmic Axion Spin Precession Experiment (CASPEr)

Author: Derek Kimball[1]

[1] *California State University - East Bay*

Corresponding Author: derek.jacksonkimball@csueastbay.edu

The nature of dark matter is a key problem in modern physics, and it is important to develop techniques to search for a wide class of dark-matter candidates. Axions, originally introduced to resolve the strong CP problem in Quantum Chromodynamics (QCD), and axion-like particles (ALPs) are strongly motivated dark matter candidates. Nuclear spins interacting with a background axion/ALP field experience an energy shift which oscillates at a frequency equal to the axion/ALP Compton frequency. The Cosmic Axion Spin Precession Experiment (CASPEr) uses precision magnetometry and NMR techniques to search for the effects of this interaction. The experimental signature is precession of the nuclear spins under the condition of magnetic resonance: when the bias magnetic field is tuned such that the nuclear spin sublevel splitting is equal to the axion/ALP Compton frequency. These experiments have the potential to detect axion-like dark matter in a wide mass range (10^{-12} eV to 10^{-6} eV) and with coupling strengths many orders of magnitude beyond the current astrophysical and laboratory limits, and eventually all the way down to the QCD axion.

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Upper critical field of type 2 superconductor under vertical and parallel DC magnetic field.

Author: Won-Jun Jang[1]

Co-authors: Danho Ahn [2]; Dojun Youm [2]; Jhinhwan Lee [2]; Yannis Semertzidis [2]; chanyoung Lim [2]

[1] *Center for Axion and precision physics research center*

[2] *Department of physics, Korea advanced institute of science and technology*

Corresponding Author: jwj8125@gmail.com

For the successful measurement of cold dark matter, AXION, it is necessary for the development of the high Q superconducting radio frequency (RF) cavity working under high DC magnetic field. For it, type 2 superconducting materials with high critical field and high critical temperature have been suggested. Unlike type 1 superconducting materials, type 2 superconducting materials have the vortex state between the first and the second critical field, respectively, which is the first and the second order thermo dynamic transition. Therefore, it is needed to study the RF characteristics of type 2 superconducting materials in the vortex state.

Before a magnetic field dependent RF study of type 2 superconducting materials, we study the upper critical field of alloy superconductor NbTi under vertical and parallel DC magnetic field using four probe measurement. Magnetic field dependent critical temperatures of NbTi film show the difference as the DC magnetic field direction applied on NbTi film. From the discrepancy between them, we report on the optimal conditions of type 2 superconducting film for the application on high Q superconducting RF cavity for AXION measurement.

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Symmetry Breaking in Haloscope Microwave Cavities

Author: Ian Stern[1]

Co-authors: David Tanner [1]; Neil Sullivan [1]; Pierre Sikivie [1]

[1] *University of Florida*

Corresponding Authors: tanner@phys.ufl.edu, ianstern@aol.com

Axion haloscope detectors use microwave cavities permeated by a magnetic field to resonate photons converted from axions via the Primackoff effect. The sensitivity of a detector is proportional to the coupling of the cavity's search mode to the axion conversion. Transverse symmetry breaking is used to tune the search modes for scanning across a range of axion masses. However, computer simulations show transverse and longitudinal symmetry breaking reduce mode-to-conversion coupling. Simulations also show longitudinal symmetry breaking leads to other undesired consequences like mode mixing and mode crowding. These results further complicate axion dark matter searches, requiring mode identification techniques. The effects of symmetry breaking on haloscope cavity modes will be presented along with mode identification techniques.

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First test of a photonic band gap structure for ADMX-HF

Author: Samantha Lewis[1]

[1] *University of California - Berkeley*

Corresponding Author: smlewis@berkeley.edu

Haloscopic axion searches require the tuning of a TM mode in a microwave cavity. Traditional cavities contain many unwanted modes which can result in mode crossings, ultimately reducing the effective tuning range of a cavity and slowing scan rates. Photonic band gap (PBG) structures have the potential to create resonators without TE modes, allowing for uninterrupted tuning. A tunable PBG structure has been designed for ADMX-HF. A prototype has been built and tested to validate simulations. Results of the fixed frequency case will be shown as well as details of the expected tuning.

This work was supported under the auspices of the National Science Foundation, under grants PHY-1067242 and PHY-1306729and the Heising-Simons Foundation under grant 2014-182.

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Introduction to RF-Structures and Their Design

Author: Frank Krawczyk[1]

[1] *Los Alamos National Laboratory*

Corresponding Author: fkrawczyk@lanl.gov

The numerical design presentation addresses two topics: (1) Numerical Methods that include resonator design basics, introduction to Finite Difference, Finite Element and other methods, and (2) Introduction to Simulation Software that covers 2D and 3D software tools and their applicability, concepts for problem descriptions, interaction with particles, couplers, mechanical and thermal design, and finally a list of tips, tricks and challenges.

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Application of the Bead-Perturbation Technique to a Study of a Tunable 5 GHz Annular Cavity

Author: Nicholas Rapidis[1]

[1] *University of California, Berkeley*

Corresponding Author: rapidis@berkeley.edu

Microwave cavities for a Sikivie-type axion search are subject to several challenging constraints. In the fabrication and operation of such cavities, often used at frequencies where the resonator is highly overmoded, it is important to be able to reliably identify the symmetry of the mode of interest, confirm its form factor, and to determine the frequency ranges where mode crossings with intruder levels have caused unacceptable admixing of the purity of the mode of interest. A simple and powerful diagnostic for mapping out the electric field of a cavity is the bead perturbation technique. While a standard tool in accelerator physics, we have for the first time applied this technique to cavities used in the axion search. In this talk, I will report initial results from an extensive study for the initial cavity used in ADMX-HF. This is an annular resonator of 25.4 cm x 10.2 cm diameter, with an off-center 5.1 cm diameter pivoted copper tuning rod, for which the TM(010) mode could be tuned over the 3.4-5.8 GHz range. Two effects in particular have been investigated, i.e. the role of rod misalignment in mode localization, and mode-mixing at avoided crossings of TM and TE modes. These results are being brought together with precision metrology and high-fidelity simulations.

This work was supported under the auspices of the National Science Foundation, under grant PHY-1306729, and the Heising-Simons Foundation under grant 2014-182.

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Multi Cavity Array for Axion Dark Matter Experiment

Author: joseph gleason[1]

Co-authors: David Tanner [2]; Neil Sullivan [1]; Pierre Sikivie [1]

[1] *UF*

[2] *University of Florida*

Corresponding Author: gleason@phys.ufl.edu

The current version of ADMX (Axion Dark Matter Experiment) utilizes a single 1 meter long by 0.5 meter diameter RF cavity to search for axion to photon decay with resonance frequencies ranging from ~580 to 890 MHz. We investigate the use of the current ADMX experimental space for the detection of axion decay in the range of 1.0 to 2.0 GHz. In order to maximize the detector volume available we propose an array of 4 or 8 mode-locked RF cavities with 15cm diameters to replace the current single cavity detector. In our design we propose a single rotor tuning rod array which minimizes gaps as well as differences in rod motion within the cavities. Utilizing cavities of different lengths we are able to reduce the effects of critical mode crossings.

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Workshop Closeout

Corresponding Author: carosi2@llnl.gov

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The QUAX experiment

Author: Nicolò Crescini[1]

[1] *Univesity of Padua*

Corresponding Author: nicolo.crescini@phd.unipd.it

We present a proposal to search for QCD axions with mass in the 200 μeV
range, assuming that they make a dominant component of dark matter. Due
to the axion-electron spin coupling, their effect is equivalent to the application of an oscillating rf field with frequency and amplitude fixed by the axion mass and coupling respectively. This equivalent magnetic field would produce spin flips in a magnetic sample placed inside a static magnetic field, which determines the resonant interaction at the Larmor frequency. Spin flips would subsequently emit radio frequency photons that can be detected by a suitable quantum counter in an ultra-cryogenic environment. An updated report of the experimental results will be presented, together with a projection of future improvements to be tested.

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Josephson Parametric Amplifiers for Axion Searches

Author: Yanjie Qiu[1]

Co-author: Irfan Siddiqi [1]

[1] *Quantum Nanoelectronics Laboratory, University of California, Berkeley*

Corresponding Author: yqiu@berkeley.edu

Measurement of weak signals consisting of few microwave photons requires multiple amplification stages for efficient detection by room temperature electronics. However, state-of-the-art commercially available microwave amplifiers add the equivalent of tens of photons of noise, making them insufficient for the amplification of single- or sub-photon signals. Interest in measuring photon-level signals from superconducting circuits has motivated the intensive development of Josephson parametric amplifiers (JPAs), which have become workhorses of the superconducting qubit field. The robustness and near quantum-limited noise performance of the JPA also make it an appealing candidate for detecting small microwave signals in axion-search experiments. In this talk, we present a brief introduction to JPAs along with an update on devices fabricated and characterized for ADMX.

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Detecting Axion Dark Matter with Superconducting Qubits

Author: Akash Dixit[1]

Co-authors: Aaron Chou [2]; David Schuster [3]

[1] *University of Chicago*

[2] *Fermilab*

[3] *U.Chicago*

Corresponding Author: avdixit@uchicago.edu

The Axion Dark Matter eXperiment (ADMX) aims to detect dark matter axions converting to single photons in a resonant cavity bathed in a uniform magnetic field. A qubit (two level system) operating as a single microwave photon detector is a viable readout system for ADMX and may offer advantages over the quantum limited amplifiers currently used. When weakly coupled to the detection cavity, the qubit transition frequency is shifted by an amount proportional to the cavity photon

number. Through spectroscopy of the qubit, the frequency shift is measured and the cavity occupation number is extracted. At low enough temperatures, this would allow sensitivities exceeding that of the standard quantum limit.

Summary:

I will describe the development of the microwave cavity structure that is designed to transfer energy from the axion dark matter field and interact with a transmon qubit. I will present the progress in fabricating transmon qubits and the various challenges encountered. I would like to have an open discussion about the measurement protocol (pulse sequence) and identify possible sources of noise (false positives from spuriously excited qubit, …).

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Evaluation of Commercial Phase Shifters for Cryogenic Applications

Author: Richard Bradley[1]

[1] *NRAO NTC*

Corresponding Author: rbradley@nrao.edu

Details of our work on evaluating commercial phase shifters for cavity impedance matching at cryogenic temperatures are presented. A brief overview of the circuitry is given followed by information on two candidate phase shifters – one surface mount and one packaged. The test and modelling procedures for both bench and cryogenic measurements are outlined. Initial cryogenic measurements indicated no variation in phase with bias voltage – this problem was traced to the use silicon varactors in these commercial units. The circuit topologies were studied and GaAs varactor replacements are being ordered.

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TE Mode Ridged Waveguide Cavities for ADMX Research

Author: Alfred Moretti[1]

[1] *Fermilab*

The talk will cover the application of Ridged waveguide cavities for ADMX research. Designs are given that cover the frequency ragne of 2 GHz to 20 GHz. Their Q's, Coupling Form Factor, and tolerances will be presented. These cavities resonate in the lowest order TE 100 mode because of their long length.

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Work on Superconducting Aluminum Cavities

Author: Katsuya Yonehara[1]

Co-author: Alfred Moretti [1]

[1] *Fermilab*

Current efforts on studying aluminum superconducting cavities at Fermilab will be presented.

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Introduction & Welcome

Author: Gianpaolo Carosi[1]

[1] *Lawrence Livermore National Laboratory*

Corresponding Author: carosi2@llnl.gov

In this talk I will discuss the motivation behind this workshop by introducing the dark matter axion and the haloscope technique to search for it. This technique uses microwave cavities to resonantly enhance the conversion rate of axions to potentially detectable levels. I will layout the number of design challenges facing experimental efforts moving forward.

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Electronic tuning with dielectrics

Author: Daniel Bowring[1]

Co-authors: Alvin Tollestrup [2]; Andrew Sonnenschein [1]; Shashank Priya [3]; Sreenivasulu Gollapudi [3]

[1] *Fermilab*

[2] *FNAL*

[3] *Virginia Tech*

Corresponding Author: dbowring@fnal.gov

Axion searches above ~1 GHz will employ multiple resonators locked to the same frequency. Fine tuning of individual resonators may be accomplished using thin films of strontium titanate (STO) and related materials, whose dielectic strength can be varied through DC voltage bias. We have developed a method to evaluate these films using coplanar waveguide
resonators. We will discuss the asssessment of the resonator system and films at room temperature and at cryogenic temperatures.