ADMX Status Update

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Outline

1. Introduction to Axions
2. Experimental Setup
3. Upgrades for Gen-2
4. Research In Progress
Axion: what is it?

- could explain why CP violation is so small in QCD
- dark matter candidate
- low energy observable of high energy scales
How do we look for it?

QCD axion has the following properties:

- $g \propto m_a$  \hspace{2cm} \left( g \propto 1/f_a \right)$

- there is a generic coupling to two photons: $g_{a\gamma\gamma}$

$L_I = g_{a\gamma\gamma} a \vec{E} \cdot \vec{B}$
Exclusions from Microwave Cavity Expts

adapted from J. Vogel’s thesis
Experimental Handles

- Microwave cavity
- ADMX
- ADMX-HF
- KAIST
- CARRACK

- Solar helioscopes
- CAST
- SUMICO
- ALPs
- CROWS
- YMCE

- Oscillating EDM
- CASPER

- Spin-polarized forces
- Eöt-Wash
- Ariadne
- ILL
- Indiana
$g_{\alpha\gamma\gamma}$ exclusions

from D. Cadamuro’s thesis
ADMX Collaboration

experimental site as of November 2014
Experiment
Measurement Technique

observed power depends on:
- magnetic field
- cavity quality factor
- electric field distribution
- axion-photon coupling
- local dark matter density
Scanning Rate

\[ \text{Scan Rate} = \frac{\text{cavity BW}}{\tau} \propto \frac{1}{T_{\text{sys}}^2} \]

\[ T_{\text{sys}} = T_{\text{cavity}} + T_{\text{amplifier}} \]
Quantum-Limited Amplifiers

modify DC SQUIDs to work with RF inputs. These microstrip SQUID amplifiers are quantum-limited devices.

Darin Kinion, JC
Upgrades

1. Data taking on Two Channels
2. Tunable SQUID
3. Dilution Refrigerator
4. Side Cavity @ 4 GHz
5. JPA on Channel 2 line
Data Taking on Two Channels

Results from 2014
Anticipating Mode Crossings

Went from 2D to 3D E&M simulations.

work of D. Lyapustin
Tunable Microstrip SQUID Amplifiers

work of Sean O’Kelley

quantum limited performance

20% tuning range
Dilution Refrigerator

operating at $T_{sys} = 200$ mK, cooling power of 800 $\mu$W.

Currently leak checking the gas handling system. Commissioning runs scheduled for end of summer 2015.
JPA + Side Cavity

Josephson Parametric Amplifier on second channel.

made by Siddiqi group at Berkeley.

Cavity @ 3.9+ GHz, will be able to reach $g \sim 10^{-14} \text{ GeV}^{-1}$

work of C. Boutan
Research In Progress

Prototypes

- Low Frequency: LC circuits
- High Frequency: Dielectric in Cavities; Bent Waveguide
LC Circuits

- Use resonant circuits for low frequencies when cavity size becomes unwieldy.
- Tune capacitance to change resonance.

LC loop made of copper stock.

LC loop printed on PCB trace.
Dielectric in Cavities

dielectric plates in waveguide break symmetry between positive and negative E field so that

$$\int_{V} \vec{E} \cdot \vec{B}_{ext} \, dz \neq 0$$

work of J. Sloan
Bent Waveguide

Slide from A. Chou

Bend waveguide to maximize overlap of $E$ and external $B$. S. Kazakov (TD)

Tune by adjusting transverse boundary conditions, keeping slot sufficiently small to avoid excessive power leakage.

Power combine the output of many such waveguides to make up for the loss in volume.
ADMX is a direct search for dark matter axions.
Commissioning Runs begin end of summer 2015; sensitivity to furthest edge of axion model band.
Frequency coverage of factor of 2; can reach higher frequencies with less sensitivity using side cavity.
Prototype experiments for lower and higher frequencies under development.