Characterization of Nonlinear Dielectric Films for the Tuning of Microwave Cavities for Axion Searches

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Abstract

The axion is a hypothetical particle that can solve the strong CP problem and be the primary component of dark matter in the universe. Experiments such as the Axion Dark Matter eXperiment (ADMX) hope to find the axion through its coupling to photons. By tuning cavity resonance frequency, the corresponding axion mass range can be scanned. For axion searches above ~1 GHz, future generations of ADMX may use an array of small cavities locked to the same frequency. These cavities will be coarsely tuned using a tuning rod as is done in the current generation of ADMX, but fine-tuning of individual resonators will be necessary for multi-cavity arrays. A candidate fine-tuning method uses nonlinear dielectric films inside the cavities. DC-biasing the films changes their dielectric constant, affecting the frequencies of cavity modes. This method makes frequency-matched-resonator arrays more practical by saving space and minimizing heat load inside the cryostat. This poster presents RF design and simulation and preliminary testing on the coplanar waveguide resonators used to test the films.

Nonlinear Dielectric Materials

- Candidate fine-tuning method
- Dielectric constant changes nonlinearly with applied DC bias voltage
- Individual cavities’ resonance frequencies can be shifted using films with different applied voltages.

Characterizing the Films

- Coplanar waveguide (CPWG) resonator testing setup with a square film of strontium titanate (STO) nonlinear dielectric film over the resonator
- Adjusting the bias voltage on the dielectric square shifts the resonance of the board, moving the peak in its transmission spectrum

Results

- Matched resonance peak of bare board from simulation and data (See Figure 7.)
- Observed frequency shifting in simulations by changing the dielectric constant of the film square.

Future Work

- Test the CPWG resonators in the PPMS system.
- Implement and test the films in resonator cavities.

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References