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Broadband Electric-field Axion Sensing Technique (BEAST)

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The mass of axion dark matter is only weakly bounded by cosmological observations, necessitating a variety of detection techniques and experiments at many different mass ranges. Axions are calculated to convert to photons via the inverse Primakoff effect and cryogenic resonant cavities are often proposed as a tool for detecting these photons. However, such structures are inherently narrowband and the range of possible axion dark matter masses spans several orders of magnitude. On the other hand broadband low-mass particle haloscopes have been proposed using inductive magnetometer sensors and a solenoid magnet of gapped toroidal geometry. In this work we propose an alternative approach, which uses a capacitive sensor in a conventional solenoidal magnet with the magnetic field aligned in the laboratory z-axis, as implemented in standard haloscope experiments. In the presence of a large DC magnetic field, the inverse Primakoff effect causes a time varying electric field (or equivalent displacement current) in the z-direction to oscillate at the axion Compton frequency. We propose non-resonant techniques to detect this electric field by implementing capacitive electric field sensors coupled to a low noise amplifier. We present the theoretical foundation for this proposal, and the first experimental results. Preliminary results constrain $g_{a\gamma\gamma} >\sim 2.35 \times 10^{-12}$ GeV^{-1} in the mass range of 2.08×10^{-11} to 2.2×10^{-11} eV, and demonstrate potential sensitivity to axion like dark matter with masses in the range of 10^{-12} to 10^{-8} eV.

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