Broadband Axion Dark Matter Haloscopes via Electric Sensing

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The mass of axion dark matter is only weakly bounded by cosmological observations, necessitating a variety of detection techniques over several orders of magnitude of mass ranges. Axions haloscopes based on resonant cavities have become the current standard to search for dark matter axions. Such structures are inherently narrowband and for low masses the volume of the required cavity becomes prohibitively large. Broadband low-mass detectors have already been proposed using inductive magnetometer sensors and a gapped toroidal solenoid magnet. In this work we propose an alternative, which uses electric sensors in a conventional solenoidal magnet aligned in the laboratory z-axis, as implemented in standard haloscope experiments. In the presence of the DC magnetic field, the inverse Primakoff effect causes a time varying electric vacuum polarization (or displacement current) in the z-direction to oscillate at the axion Compton frequency. We propose non-resonant techniques to detect this oscillating polarization by implementing a capacitive sensor or an electric dipole antenna 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.