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Exploring Axion Dark Matter with Optical Quantum Sensors

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We recently started a project to develop a new pathfinding experiment with a new detection concept [1] to explore ultralight axion dark matter in a completely unexplored mass range near 10 neV. Our detection concept is based on a superconducting resonant inductor-capacitor (LC) circuit with an optical quantum sensor (OQS). The target signal we seek to detect is a minute axion-induced magnetic field oscillating at an angular frequency equal to axion mass. The OQS is the most sensitive non-cryogenic magnetic-field sensor, which manipulates atomic spins for sensitive magnetic sensing using alkali-metal vapor cells and lasers (for optical pumping and spin-state probing). The OQS operates at ambient temperatures without the need for expensive cryogens and complicated cryogenic infrastructure. We anticipate that the experiment would improve current sensitivities to the axion signal strength by 5-6 orders of magnitude in the project's target parameter space. Further, the experiment would create a competitive advantage in the development of new quantum sensing probes to search for axion dark matter. In this talk, we present our LC circuit-OQS axion detection concept and the projected axion sensitivity.

[1] Y. J. Kim, L. Duffy, I. Savukov, and P.-H. Chu, "Sensitivity of ultralight axion dark matter search with optical quantum sensors,"Physical Review D 108, 052007 (2023).

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