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SERAPH: Wavelike Dark Matter Searches with SRF Cavities

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Haloscopes consisting of a microwave cavity with a high quality factor (Q) connected to low-noise electronics have been deployed to detect wavelike axions and dark photons. But the dark matter mass is unknown, so haloscopes must be tunable to search through the photon coupling vs. mass parameter space. Therefore, the scan rate for haloscope experiments is a crucial figure of merit and is proportional to the cavity's quality factor. State-of-the-art experiments like ADMX currently use copper cavities with Q~80000. However, implementing superconducting cavities with Q~10^{10} can increase the instantaneous scan rate by possibly a factor of 10^5.

This presentation will report progress on the SERAPH experiment, a family of superconducting haloscopes being developed by the Superconducting Quantum Materials and Systems (SQMS) Center. In this presentation, I will first discuss the principles behind operating a haloscope whose bandwidth is much narrower than the dark matter halo energy distribution. I will then describe the first SERAPH experiments implementing a 1.3 GHz Niobium cavity with an ultra-high quality factor (Q~10^{10}) that has achieved the best sensitivity and deepest exclusion to wavelike dark photon dark matter by almost an order of magnitude. Next, I will discuss progress on the next phase of SERAPH, which will search dark photon dark matter using a widely-tunable SRF cavity (4-7 GHz). I will finally describe plans for subsequent SERAPH experiments to search for dark photons and axions with tunable SRF cavities tolerant to multi-Tesla magnetic fields and quantum sensors that subvert the Standard Quantum Limit.

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