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Superconducting cavities as detectors of ultralight bosons and high frequency gravitational waves

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Superconducting radio-frequency (SRF) cavities, renowned for their exceptionally high quality factors (~10^10), have emerged as powerful tools for probing fundamental physics beyond the Standard Model. In this talk, I will introduce the first-ever scan search for dark photon dark matter using a tunable SRF cavity, achieving unprecedented sensitivity to the kinetic mixing coefficient parameter ε . By mechanically adjusting the resonant frequency of a niobium cavity in a 2 K liquid helium environment, we scanned a 1.37 MHz range centered at 1.3 GHz, setting the world's tightest constraints on ε. Beyond terrestrial dark photon dark matter, we also demonstrate that SRF cavities can serve as sensitive detectors for galactic dark photon backgrounds, leveraging their directional sensitivity to probe potential anisotropic signals. Finally, we present a theoretical framework where an array of coupled electromagnetic detectors significantly enhances scan rates for ultralight dark matter and high-frequency gravitational waves.

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