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Towards Quantum Charge Parity Detectors with meV Resolution for sub-GeV Dark Matter Detection

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The increasingly theoretically relevant "sub-GeV" mass particle dark matter landscape requires new tools and techniques to fully investigate. In particular, the constrained kinematic space of potential interactions suggests that collective excitations like phonons may be the only signature of very low mass dark matter candidates. One promising technology to study these are qubit derived superconducting charge-parity sensors. These detection schemes include Quantum Capacitance Detectors (QCDs) and Offset-Charge Sensitive (OCS) devices, and the former have been demonstrated in previous literature as excellent far-IR photon counters with NEP of <10–20 W/Hz$^{-\!-\!-}\sqrt{}$. We seek to extend the applicability of these techniques by directly coupling the sensors to interaction induced athermal phonons generated within a crystalline silicon substrate. Such a scheme will enable the literal counting of O(100) ueV quasiparticle quanta (broken Cooper-pair electrons) within a superconducting absorber, as produced by single meV phonons. In this presentation, we will discuss progress towards demonstrating a charge-parity detector design, and lay out a roadmap for demonstrating eV and subsequently lower energy resolution in future iterations.

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