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Progress of Qubit-based Sensors for meV Phonon Detection

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With decades of null results from direct detection experiments for dark matter with mass above ˜1 GeV, sub-GeV dark matter has become an increasingly compelling alternative. At such masses, we expect meV-scale nuclear recoil energies, where phonons are the dominant energy excitation. Superconducting charge qubits demonstrate sensitivity to single quasiparticle tunneling events, a property that can be exploited to sense phonons from sub-eV energy depositions. We present two qubit-based phonon sensors utilizing this phenomenon: Superconducting Quasiparticle Amplifying Transmons (SQUATs) and Quantum Parity Detectors (QPDs). In both designs, phonons generated from an interaction within the crystalline substrate break Cooper-pairs in the superconducting metal film, increasing the quasiparticle density near the qubit junction, hence increasing the measured tunneling rate across the junction. These devices benefit from inherent multiplexability, non-dissipative operation, and exponential suppression of thermal noise with temperature. Here, we present an overview of device theory and operation, results from the first generation of device testing, and a path towards meV-scale sensitivity.

Author: SANDOVAL, Brandon (Caltech)

Co-authors: RAMANATHAN, Karthik; KURINSKY, Noah (SLAC/Stanford); GOLWALA, Sunil

Presenter: SANDOVAL, Brandon (Caltech)

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