Contribution ID: **115** Type: **Oral presentation**

Development of kinetic inductance phonon sensors for phonon-mediated dark-matter detection

Thursday 21 July 2022 16:30 (20 minutes)

Phonon-mediated particle detectors promise sub-eV threshold reach for the increasingly relevant sub-GeV dark matter (DM) parameter space. Kinetic Inductance Detectors (KIDs), exploiting superconducting material physics via Cooper-pair breaking, have particular advantages as the phonon sensors when mounted on crystalline substrates. Their inherent multiplexability, non-dissipative nature, and exponential suppression of quasiparticle population with temperature –assuming a reduction in residual quasiparticles - make them well suited for imaging the entire phonon flux across the substrate. We discuss here efforts in building two kinds of KID based DM detectors and their calibration using an optical LED setup. The first design uses a single Al KID on a gram-scale substrate, with demonstrated O(eV) resolution on energy received. The second design, optimized for background rejection, uses an array of KIDs to resolve both position and discriminate recoil types, with demonstrated O(100) eV energy resolution. We also outline plans to achieve sub-eV resolution in the next generation of devices through both the use of a quantum-limited superconducting parametric amplifier and alternative KID material selection. Finally, we present novel phonon-mediated ideas and techniques for meV-threshold DM detection, focusing on Quantum Capacitance Detectors (QCDs) derived from quantum computing charge qubits.

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Session Classification: Parallel 3A - Direct detection (calibration and new approaches)