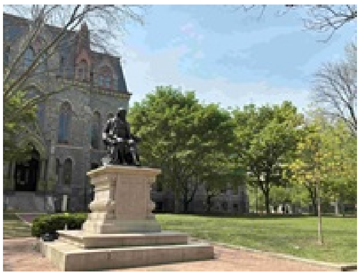

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Toward a meV Kinetic Inductance Phonon-Mediated (KIPM) detector for low mass dark matter searches

Tuesday 7 October 2025 14:45 (15 minutes)

Dark matter candidates on the mass scale of $\mathcal{O}(10-10^4)\,\mathrm{keV}$ produce $\mathcal{O}(1-10^3)\,\mathrm{meV}$ phonon excitations. Probing these low-mass dark matter candidates requires quantum sensors with meV phonon energy resolution (σ_E). Transition edge sensors (TESs) have achieved the lowest energy threshold so far, with $\sigma_E \sim \mathcal{O}(100)\,\mathrm{meV}$. On the other hand, the kinetic inductance phonon-mediated (KIPM) detectors have demonstrated 2.1 eV absorbed energy resolution ($\sigma_{E_{abs}}$) with a $\mathcal{O}(1)\%$ phonon collection efficiency. This contribution presents a pathway toward building a $\sigma_E \sim \mathcal{O}(1)\,\mathrm{meV}$ phonon-absorber-assisted (PAA) KIPM detector. Specifically, the meV KIPM energy resolution can be achieved by (1) reducing the intrinsic detector noises including the two-level-system (TLS) noise, amplifier noise, and the generation-recombination (GR) noise and (2) improving total efficiency, including the phonon collection efficiency (η_{ph}) and quasiparticle trapping efficiency (η_{trap}), to $\mathcal{O}(30)\%$ limited by the phonon pair breaking efficiency (η_{pb}), as demonstrated in quasiparticle-trap-assisted electrothermal-feedback
transition-edge sensors (QETs). Achieving both low noise and high efficiency requires implementing quasiparticle trapping, using aluminum (Al) absorbers and low T_c inductors, to enable high active Al surface coverage and small inductor volume. Detailed noise studies and efficiency characterization are conducted to predict detector performance. This contribution briefly summarizes the latest PAA-KIPM design, expected detector performance, and fabrication and testing status.

Author: XIONG, Junwen (Caltech)

Presenter: XIONG, Junwen (Caltech)

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