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Optical Strain Sensing for Particle Detection

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Optomechanical strain sensing provides attractive opportunities for novel particle detection schemes, as well as studying stress-induced (i.e. non-radiogenic) phonon bursts, which have been demonstrated to limit the coherence times of superconducting qubits and are a suspected culprit in the low energy excesses observed by many dark matter direct detection experiments. We are investigating SiN microring optical resonator strain sensors, developed at Purdue University, for applications in fundamental particle sensing and QIS. These sensors can be embedded in the substrate upon which superconducting qubits are patterned, providing a handle to distinguish decoherence events of radiogenic origin from those due to crystal stress. In a similar way, these sensors can be operated in conjunction with superconducting detectors (e.g., MKIDs, TES) to enable multi-channel readout of particle interactions in the device substrate or serve as anticoincidence detectors, which may be required to identify low-energy interactions from dark matter particles down to the fermionic thermal relic mass limit of a few keV. Such sensors can potentially be used to directly observe resonant scattering processes of gamma rays (and perhaps neutrinos) where no detectable quanta are produced in the target, via the microscopic stress induced by the momentum transfer to the (fixed-in-place) crystal lattice as a whole. These strain sensors have so far found application in photonics and communications, but have yet to be adopted for HEP uses, where they can provide unique capabilities in the search for dark matter as well as understanding and improving the coherence times of superconducting qubits.

Early Career

Yes

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