Improved strain sensitivity can extend the reach of existing experiments, and can enable new experiments.

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Embedded optical strain sensor allows for codeposition of primary detectors: Qubit, MKID, TES, CCD.

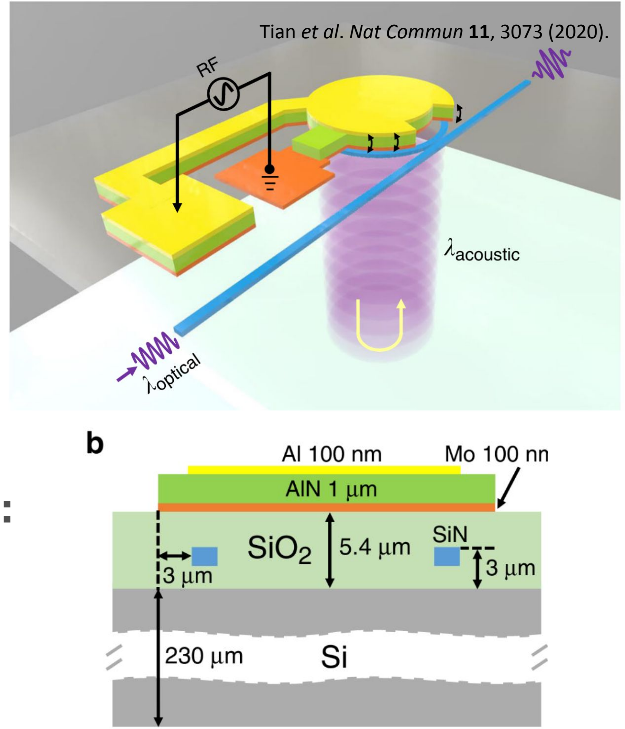
Additional readout channel: stress / substrate deformation

DM: Anticoincidence to reject low energy stress events. Potential for ER/NR discrimination?

QIS: Improve understanding of the role of stress release in quasiparticle poisoning of qubits.

Novel detection strategy for **resonant scattering processes:**

- 0 phonon final state, whole lattice recoils → no quanta
- Sufficient sensitivity to strain can identify these events
- Targeting Mössbauer-like (γ) and neutrino scattering



Full characterization of these devices for use in HEP is needed.

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Currently used in microwave-optical transduction for communication -- we are assessing for HEP applications.

- Do these sensors directly (or indirectly through phonons) respond to radiation?
- What is the spatial resolution of these devices?
- What is their energy resolution and threshold?

Initial device testing at Fermilab planned for later this year.

Currently investigating device packaging for deploying in dilution refrigerator.

Optical strain sensors can help us build better, more sensitive detectors, extending the reach of existing experiments, and offer a pathway for novel particle detection techniques.

- Investigation of low energy excesses in solid-state DM search experiments.
- Confirmation the origin of non-radiogenic quasiparticle bursts in qubits as due to stress.
- Low-threshold detection of resonant absorption of photons and possibly neutrinos.

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Thank You!

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Optical Strain Sensing for Particle Detection

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 [1,2] and are a suspected culprit in the low energy excesses observed by many dark matter direct detection experiments [3,4]. We are investigating SiN microring optical resonator strain sensors, developed at Purdue University [5], 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 also 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 strain 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, observing neutrino interactions, and improving the coherence times of superconducting qubits.

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