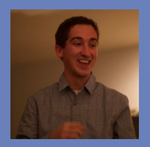
Detecting Dark Matter with a Qubit


Ankur Agrawal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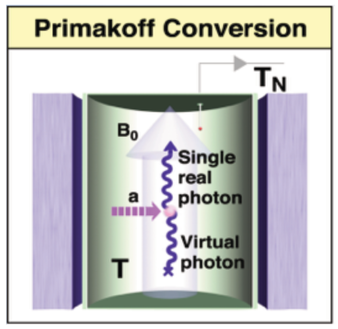
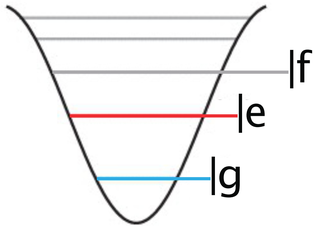
Axion Dark Matter

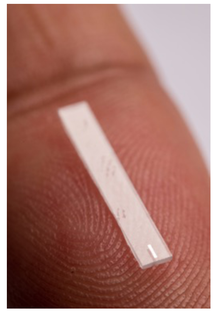
Axion model provides a solution to the Strong CP problem and accounts for the observed dark matter density

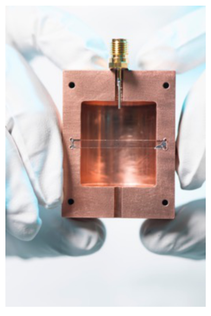
$$\mathcal{L} = g_{a\gamma\gamma} a \vec{E} \cdot \vec{B}_0$$

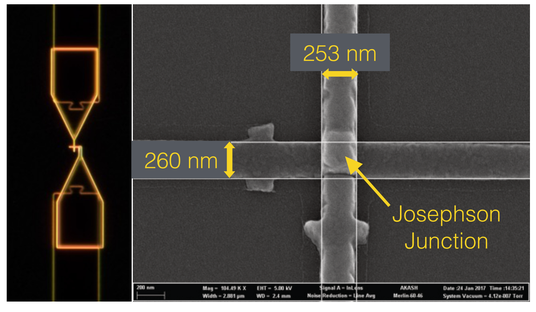


Use a superconducting qubit to enhance and detect dark matter

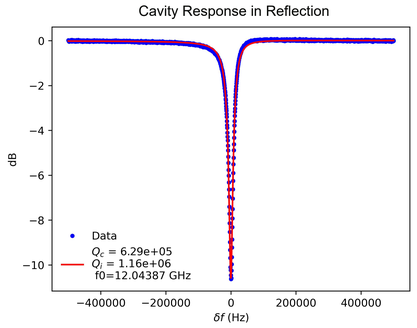








High Q Bandgap Cavity



Bandgap produced by arrangement of dielectric structures prevents radiation from leaving structure and can support high Q (~1e6) electromagnetic modes.

Photon counting with a qubit

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Searching for Dark Matter with a Superconducting Qubit

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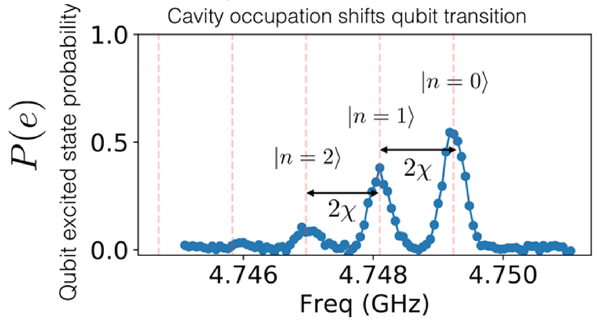
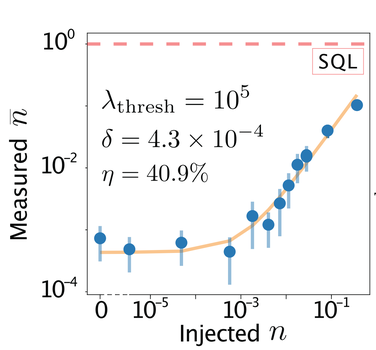
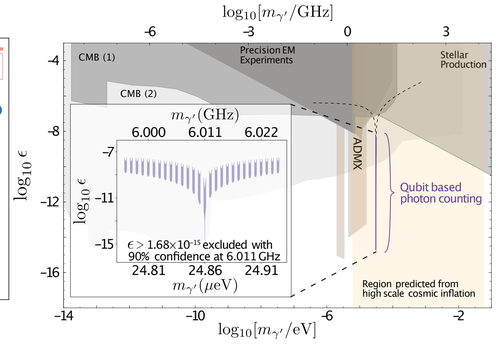


Cavity occupation imprinted on qubit transition frequency

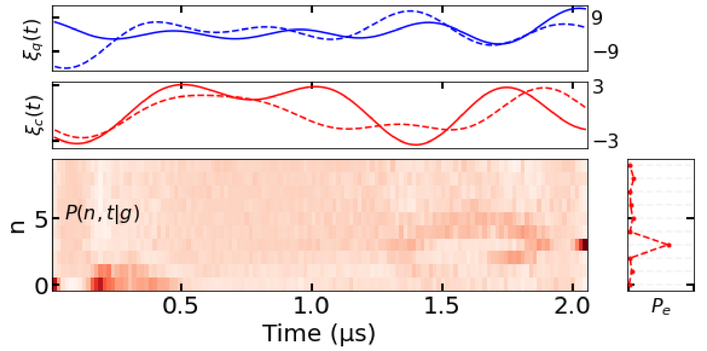
$$\mathcal{H} = \omega_c a^\dagger a + \frac{1}{2}(\omega_q + 2\chi a^\dagger a)\sigma_z$$

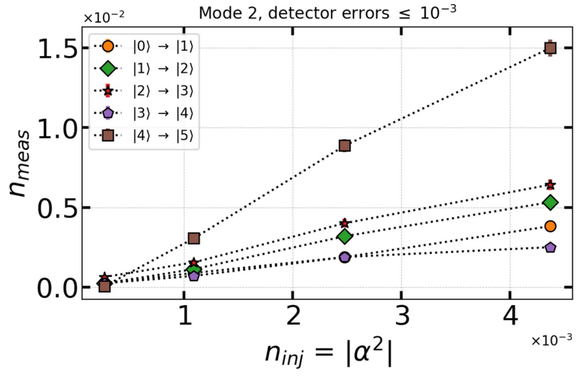




Enhancement by state preparation

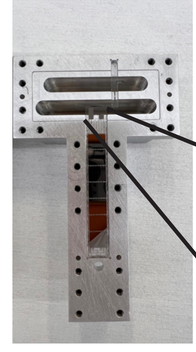
$$\left|\langle n+1|\hat{D}(\alpha)|n\rangle\right|^2 \propto (n+1)$$



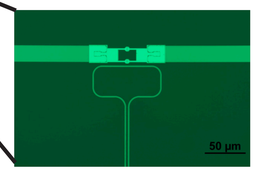


Starting cavity with more photons results in a more efficient axion search

Electronic tuning of a cavity



Tuning is required to search a range of frequencies. Applying magnetic field to loop with two Josephson junctions tunes frequency.



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