Qubit-based single photon sensors

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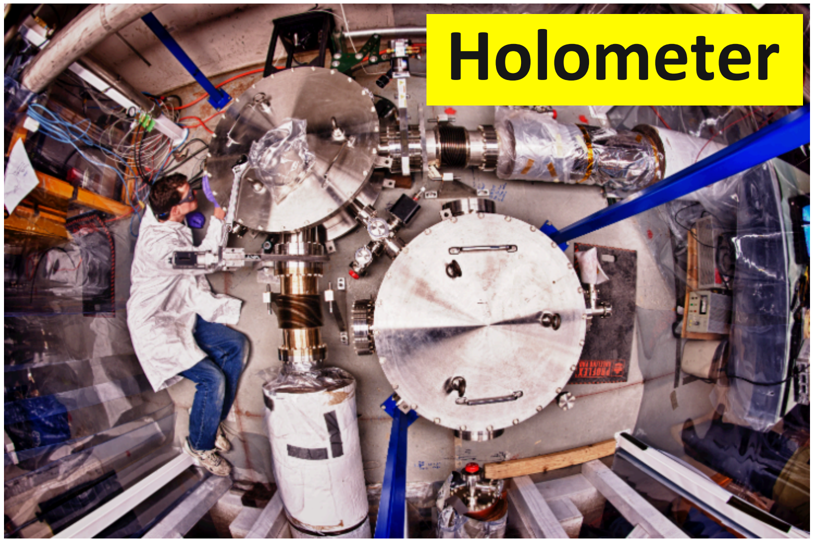
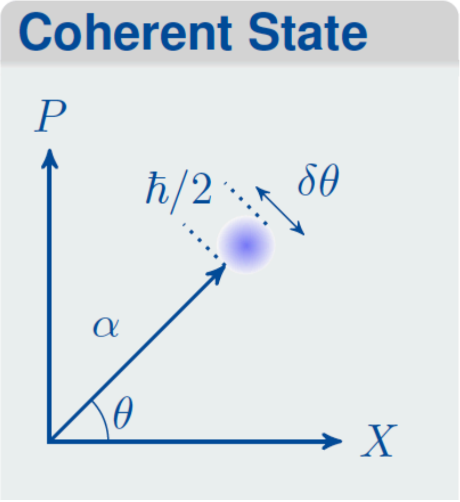
CPAD prep meeting

11/6/17

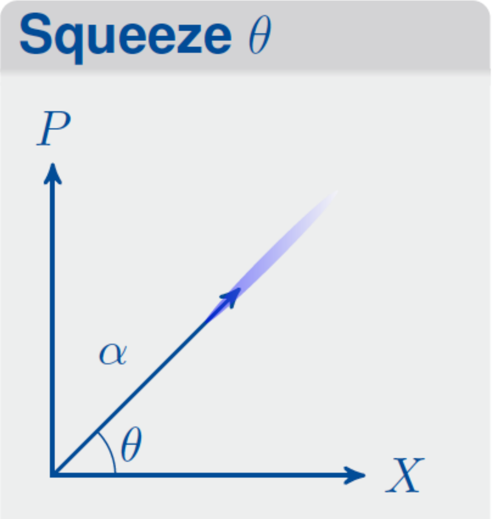
The quantum limit is flexible



(Chou, Hogan, Meyer)

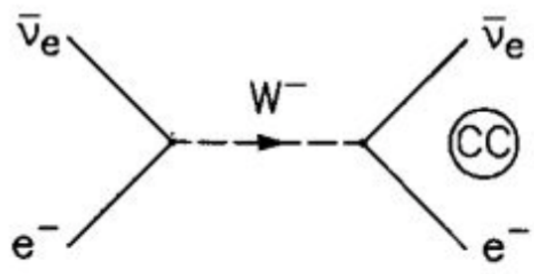


Squeezing the probe photon wavefunction makes each probe photon more valuable



Non-absorptive "off-shell" sensors

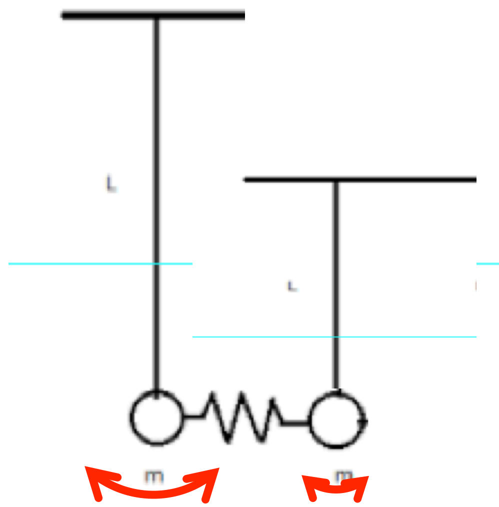
Neutrino "matter effects" (Mikheyev, Smirnov, Wolfenstein)



Sensing background electron density:
Potential energy of interaction changes the neutrino index of refraction.

No neutrinos or electrons are lost because the process occurs *far away from the W boson resonance.*

Pendula and springs



Single photon quantum

Anharmonic oscillator gets sub-quantum amplitude

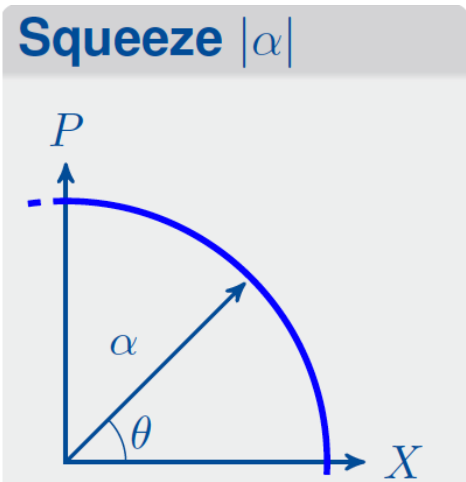
Quantum non-demolition photon sensing:
Use anharmonic oscillator weakly coupled to the photon field, and *far detuned from the photon frequency*

→ Photon mixes slightly with the sensor mode
→ No quanta are transferred
→ Sub-quantum sensor amplitude can be detected via **anharmonic frequency shift**

Haroche 2012 Nobel Prize using Rydberg atoms

Sub-quantum-limited dark matter axion detection with artificial atoms (A.Chou/D.Schuster, 3 UC grad students)

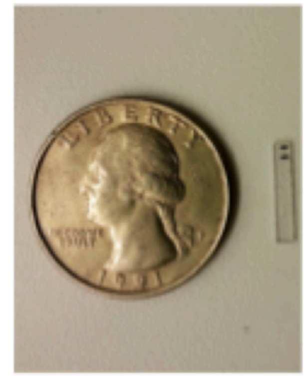
Squeeze the zero point noise with QND photon detection to see 10^{-23} W signal power

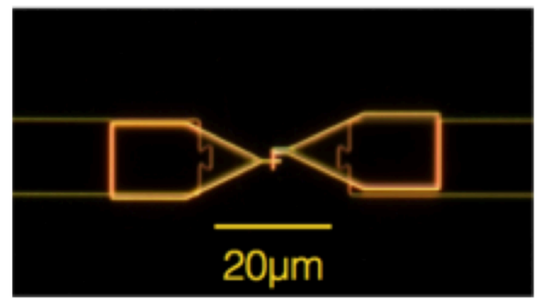


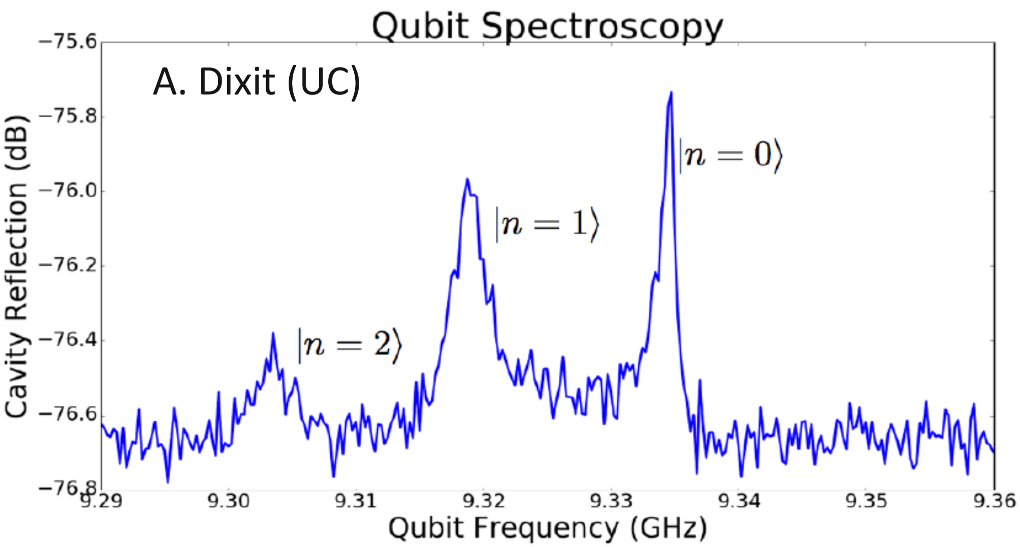
Artificial atoms based on superconducting qubits with antenna coupling to the cavity photon field.

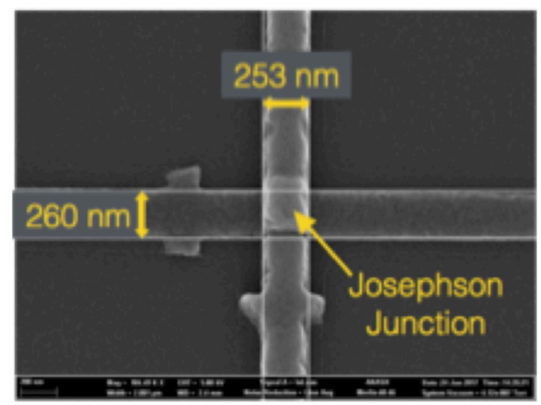
Can non-destructively sense the voltage of a single photon.

Readout noise orders of magnitude below zero-point noise.









Qubit sensors may be the **enabling technology** for high mass dark matter axion searches