Extraction of a single photon from an optical pulse

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Barak Dayan

- Principal Investigator @ Weizmann institute

- Interaction between single photons and single atoms

- Analysis of Deterministic Swapping of Photonic and Atomic States Through Single-Photon Raman Interaction. *Physical Review A.* **95 (2017)**
- Deterministic Photon-Atom and Photon-Photon Interactions Based on Single-Photon Raman Interaction. *Laser Resonators, Microresonators, and Beam Control Xviii.* **9727 (2016)**
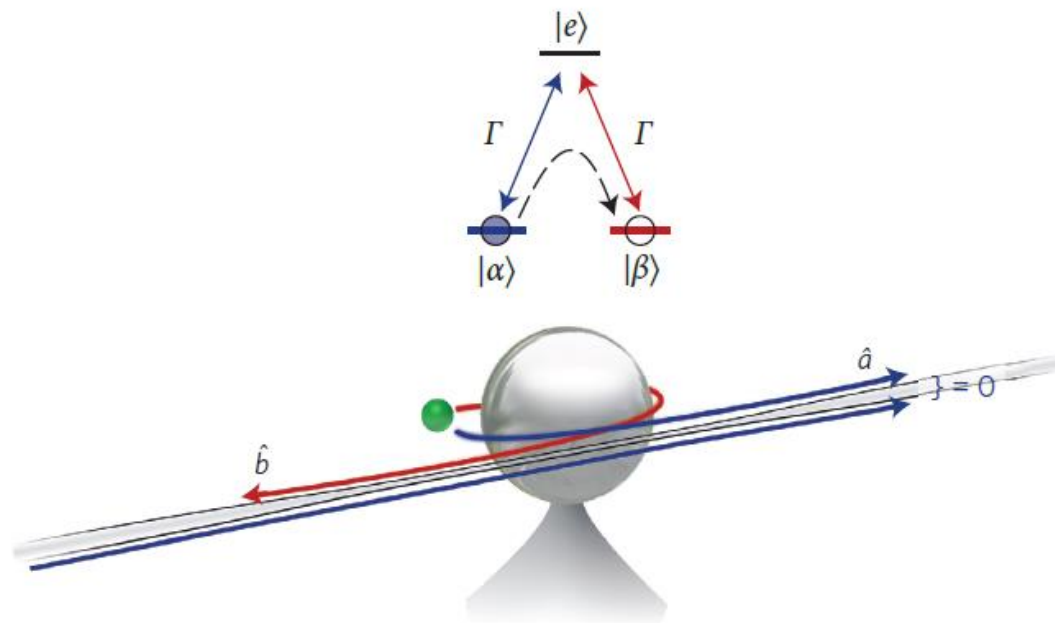
Single photon Raman interaction
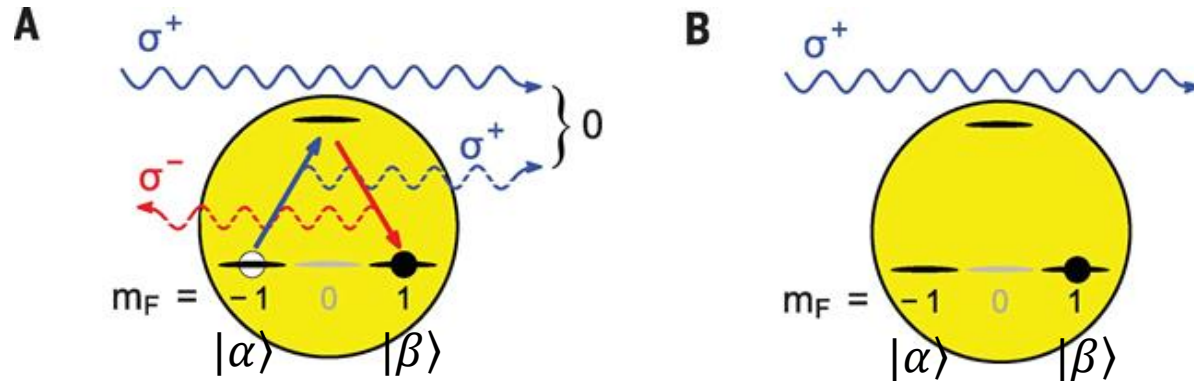
- $\sim 30 \times 10^6 \, Rb^{87}$ atoms at $\sim 7 \mu K$

- 85ns measurement pulse of varying strength

- Erasure pulse which contains ~ 1.5 photons and ~ 15ns long

Experimental scheme

- g ~ 24 MHz, γ = 3 MHz, κ_{ex} = 40 MHz

- κ_i = 6.6 MHz -> 48% linear loss

- TM whispering gallery mode : 6 % of undesired polarization

Mean number of photons

- Measured extraction efficiency ~ 40% ($n_{in} \ll 1$)

- Ideal extraction efficiency ~ 52% (due to 48% linear loss of the cavity)

- Loss can occur prior to the Raman passage of the atom to $|\beta\rangle$

- Expected # of reflected photons ~ 0.73 ($n_{in} \gg 1$)

- Measured # of reflected photons ~ 1 (n_{in} = 11) (due to interaction between ~4% undesired polarization and $|\beta\rangle$)

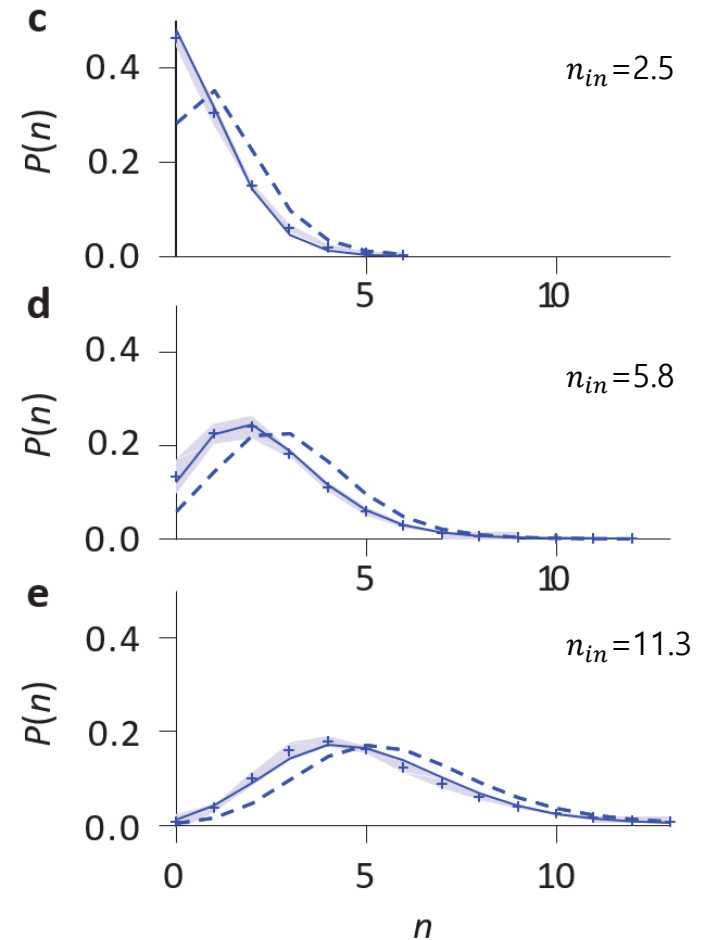**a**
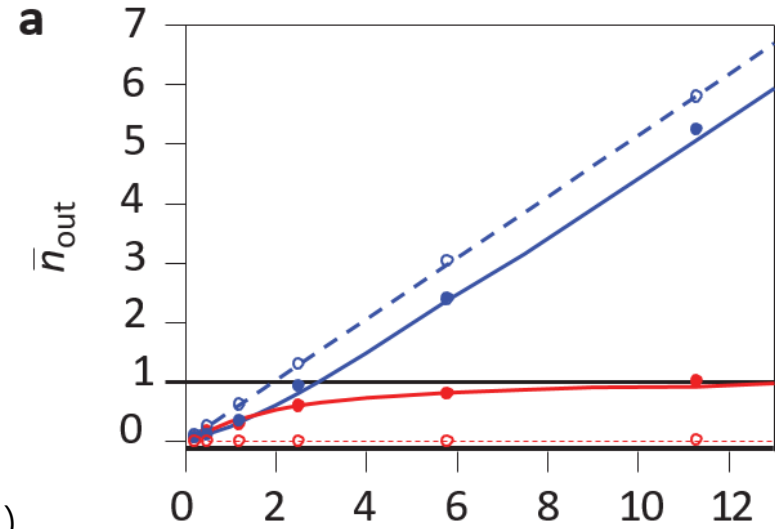
Two-photon detection prob.
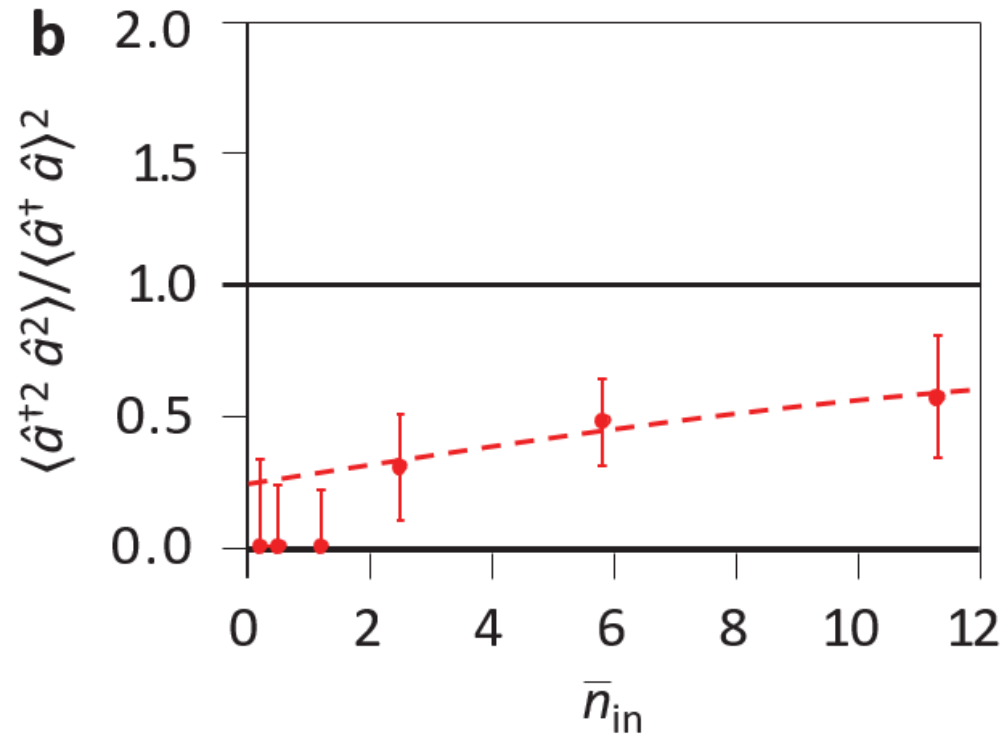
- $g^2(0) < 1$(sub-poissonian) for all input photon numbers

Photon number distribution

- Retrieval of photon number distribution

$$P(n|k) = \frac{(N - N_d)!}{(N - N_d - n)!} \sum_{i=0}^{n} \frac{\left[1 - \eta\left(1 - \frac{i + N_d}{N}\right)\right]^k}{i! \, (n - i)! \, (-1)^{n-i}}$$

- k photons input, n photons detected

- N : # of detectors

- N_d: # of alive detectors

Limitation

- Photon loss (6.6MHz -> 0.5MHz)

- Variations in the coupling strength

- Polarization impurity

Summary

- Demonstrate the deterministic extraction of a single photon from a pulse

- Reflected photon is a single photon Fock state