ETH

Correlations and Counting Statistics of an Atom Laser

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Bose-Einstein Condensate and Atom Laser

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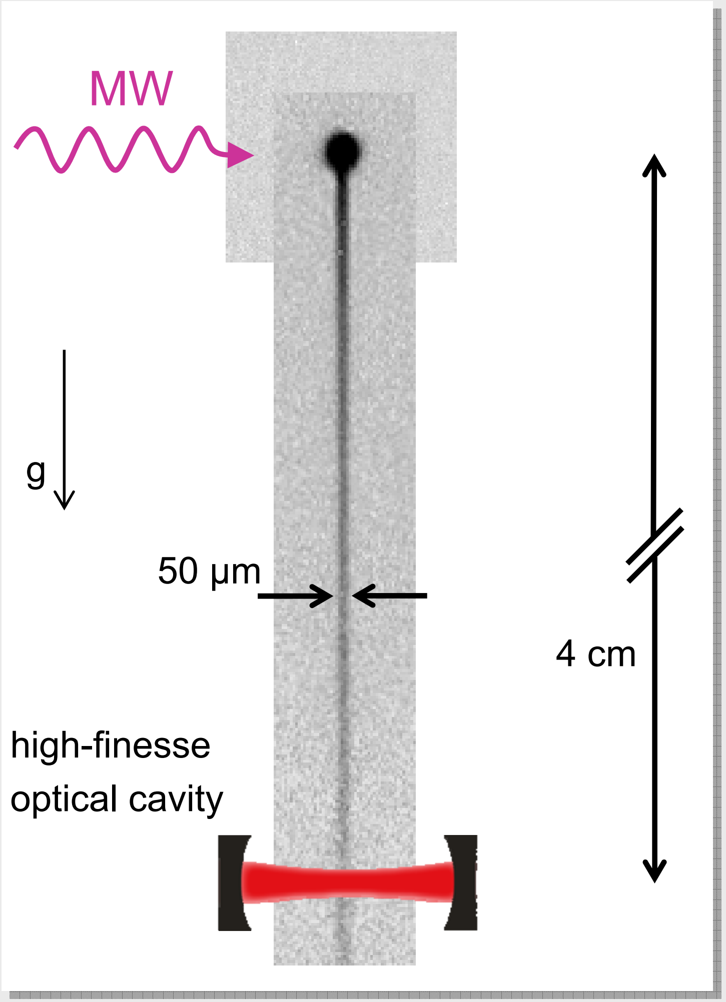
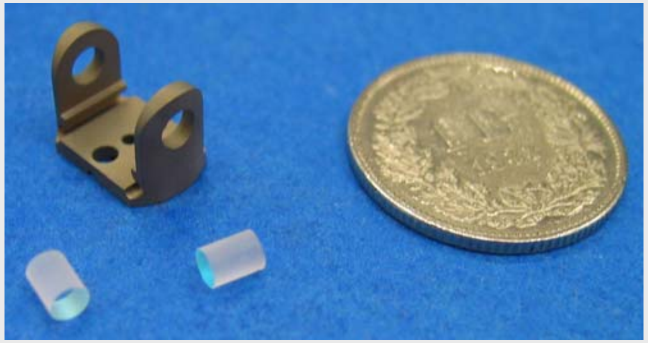
^{87}Rb condensate, 2.5×10^6 atoms

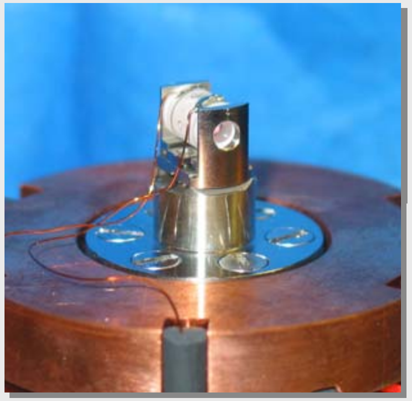


- **Single atom detection** with a good quantum efficiency

- Second order **time correlation** of the atom laser

Single-Atom Detection



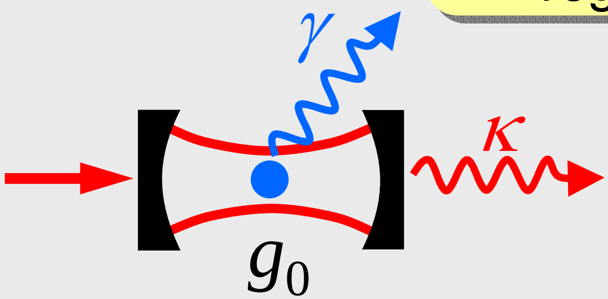


L = 178 µm

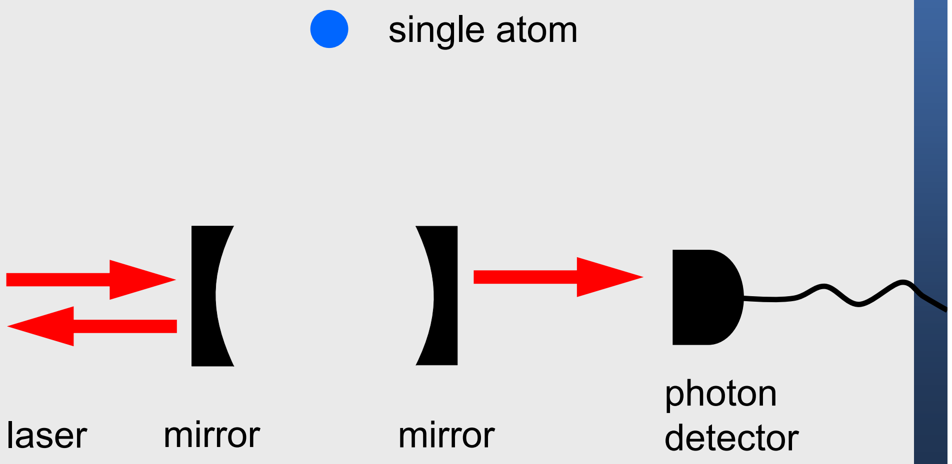
F = 300.000

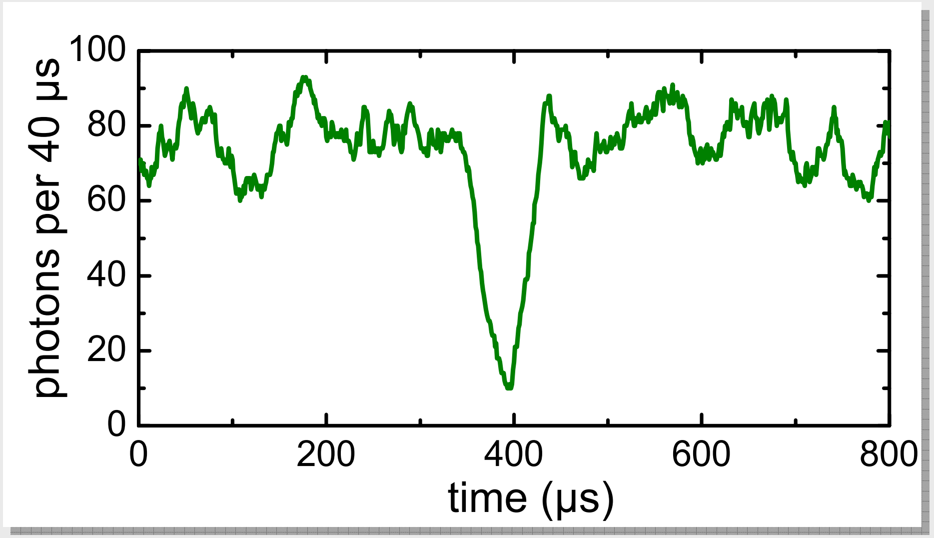
$g_0 >> \gamma, \kappa$

strong coupling regime



related work: groups of H.J. Kimble and G. Rempe





first observation by H. Mabuchi et al., Opt. Lett. **21**, 1393 (1996)

Two-particle Correlations

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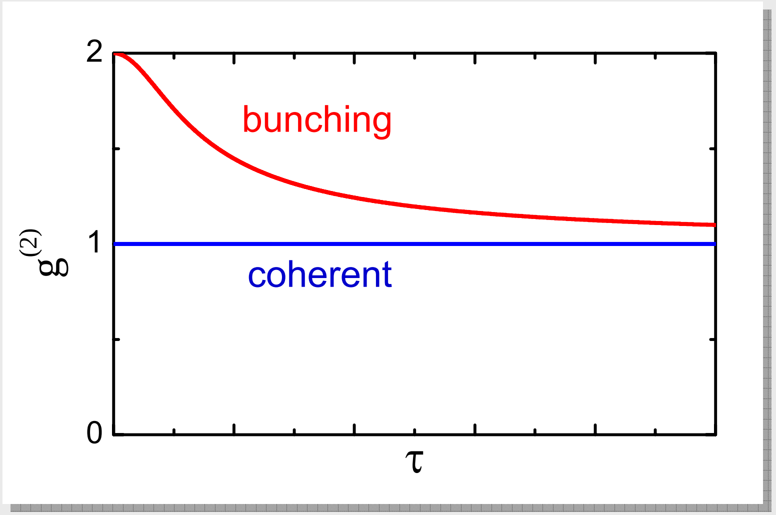
Is an atom laser a laser ?

- first-order coherence ✓ M. Köhl et al., Phys. Rev. Lett. **87**, 160404 (2001)
- second-order coherence **?**

$$g^{(2)}(\tau) = P_c(t+\tau\,|\,t) = \frac{\langle I(t)I(t+\tau)\rangle}{\langle I\rangle^2}$$

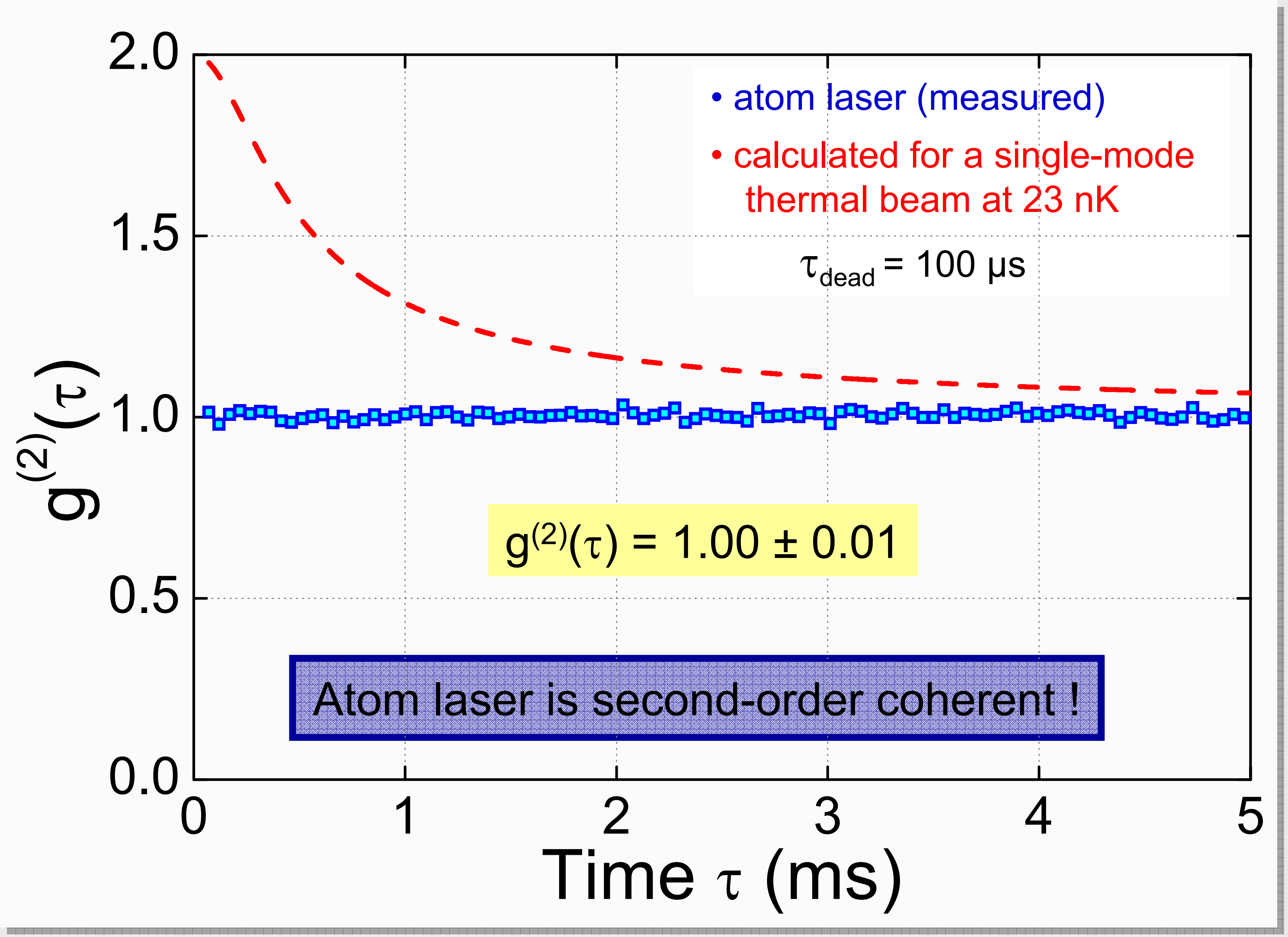


for (thermal) photons:
R. Hanbury Brown and R.Q. Twiss,
Nature **178**, 27 (1956)

for laser light:
F.T. Arecchi, Phys. Rev. Lett. **15**, 912 (1965)

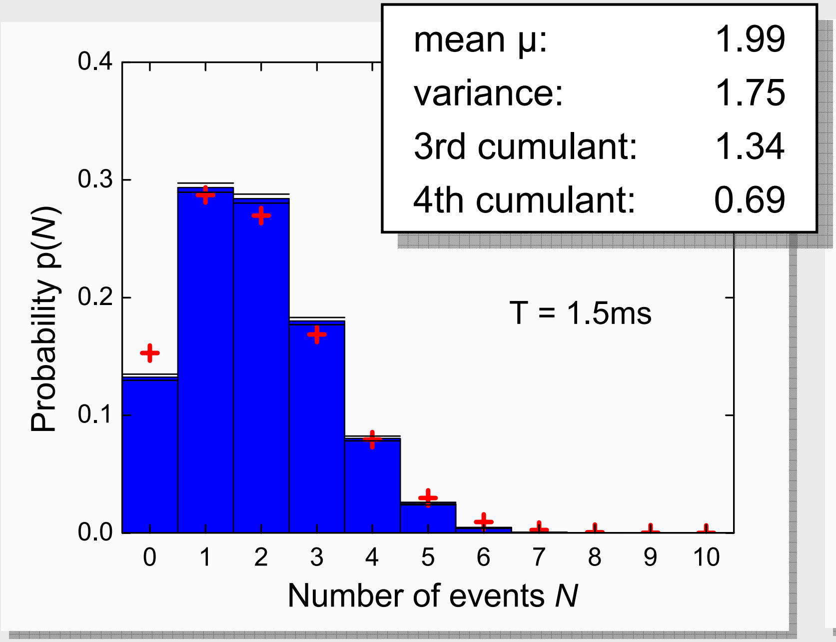
for thermal atoms:
M. Yasuda and F. Shimizu, Phys. Rev. Lett. **77**, 3090 (1996)

$g^{(2)}$ of an Atom Laser



Counting Statistics

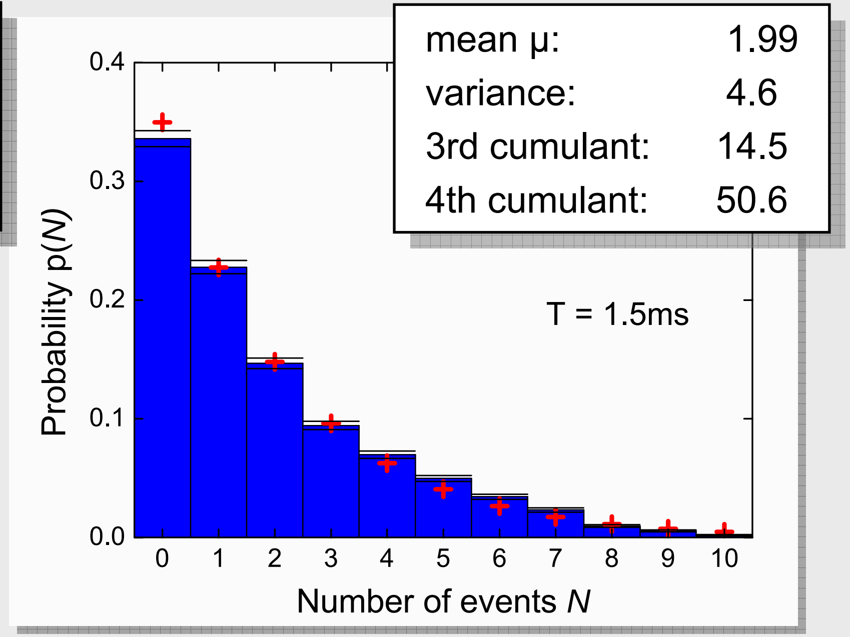
atom laser:



Poisson distribution:

$$P_\mu(N) = \frac{\mu^N}{N!} e^{-\mu}$$

pseudo-thermal:



Bose distribution:

$$P_\mu(N) = \frac{\mu^N}{(1+\mu)^{N+1}}$$

Outlook

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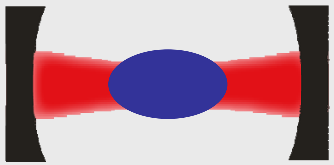
- Efficient detection of atoms extracted from a Bose-Einstein condensate

- Use heterodyne detection to coherently manipulate single atoms

- Transport of BEC into the cavity



- Optical lattice inside the cavity

→ ideal starting point for quantum computation