Memory-enabled source of multimode quantum light

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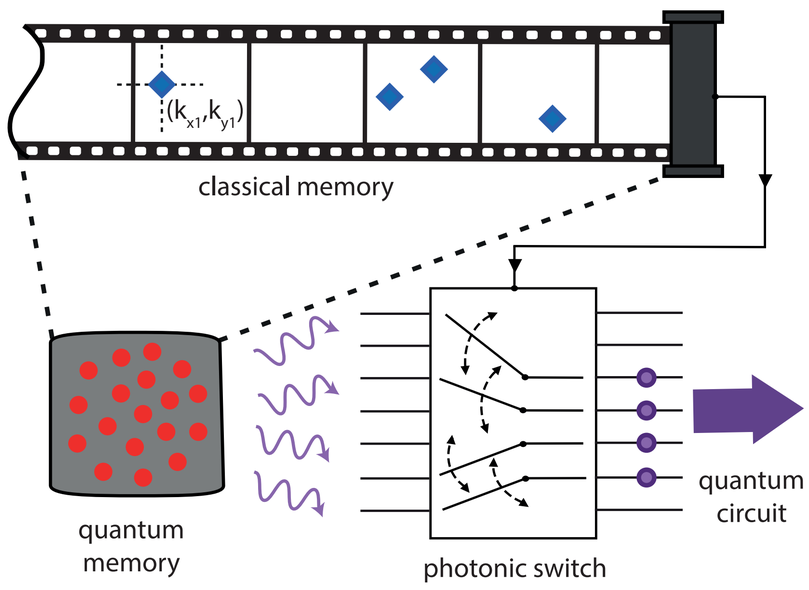
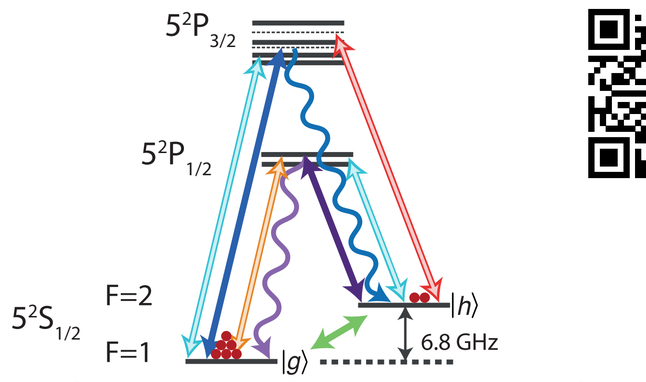
Quantum Memories Laboratory

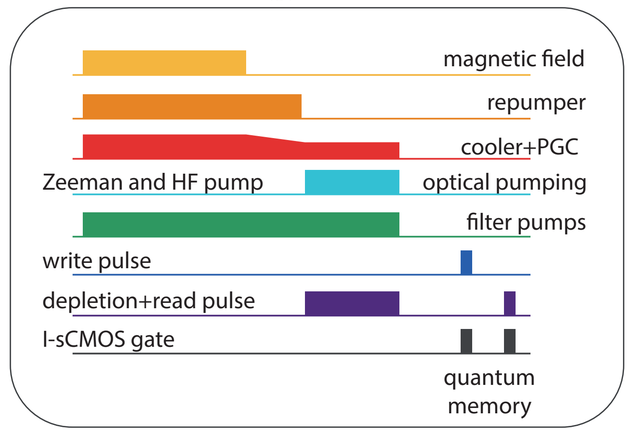
Multi-photon generation protocol

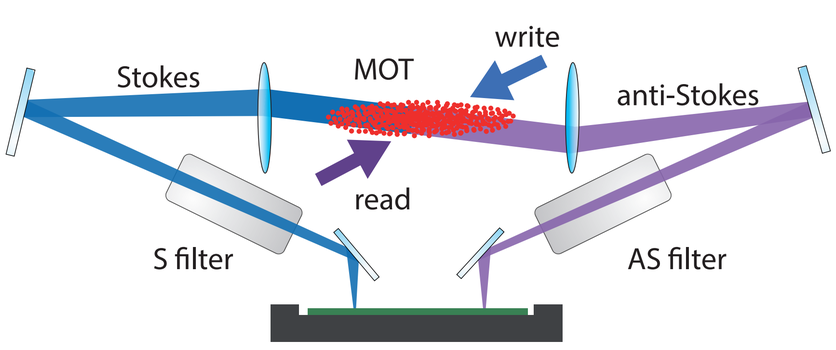
[Nat. Commun. 8, 2140 (2017), arXiv:1706.04426]

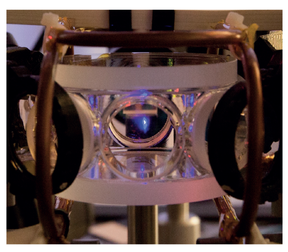
- Generate and register desired number of photons. Store measured wavevectors in classical memory.
- Calculate directions of anti-Stokes photons from phase matching relations.
- Reconfigure photonic switch to redirect photons to quantum circuit.
- Readout stored photons.



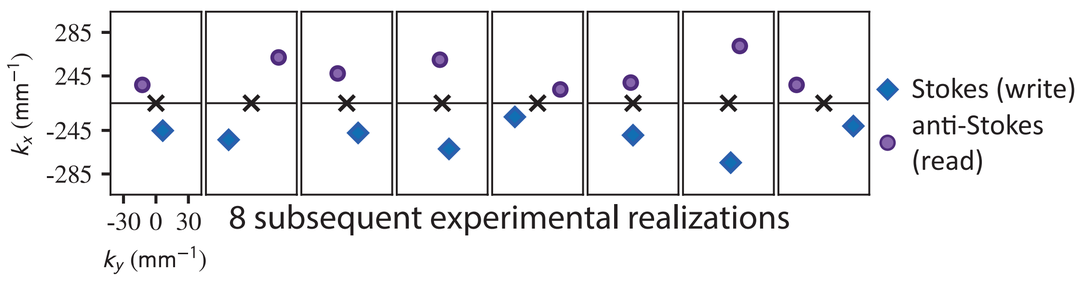




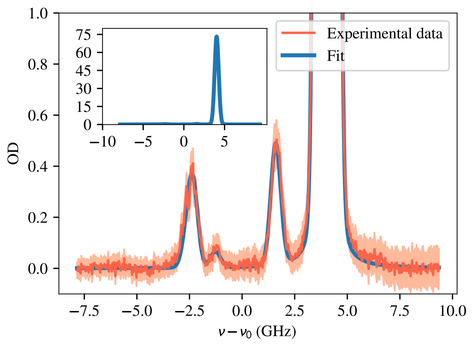




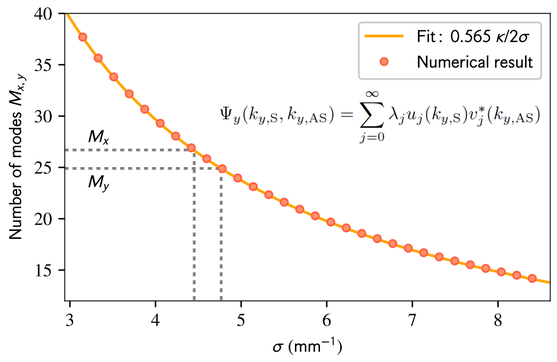
Cloud of rubidium-87 atoms at 22μK



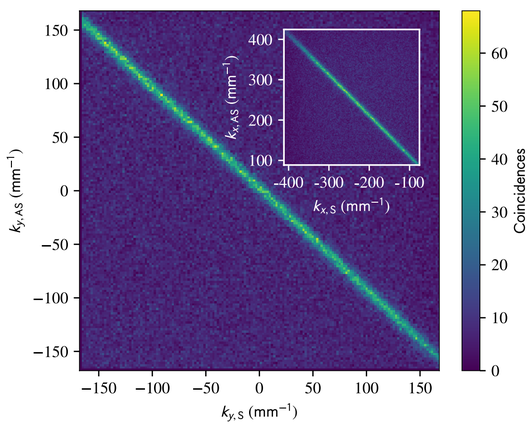
Spatially insensitive filtering with optically pumped vapor cell



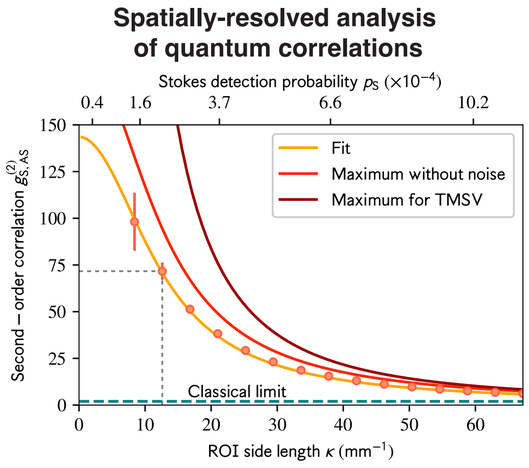
Schmidt mode decomposition of reconstructed biphoton wavefunction for capacity estimation



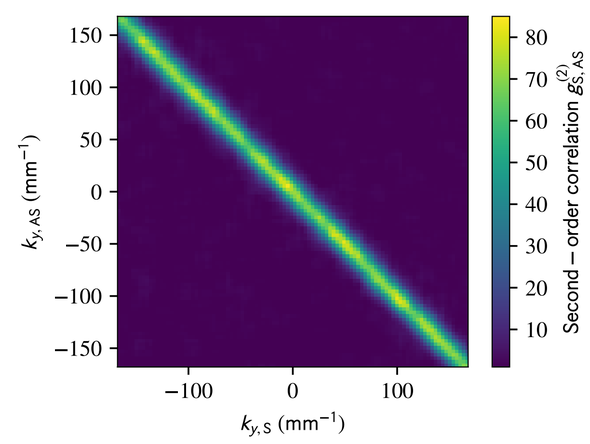
Spatial correlations and mode shape determination



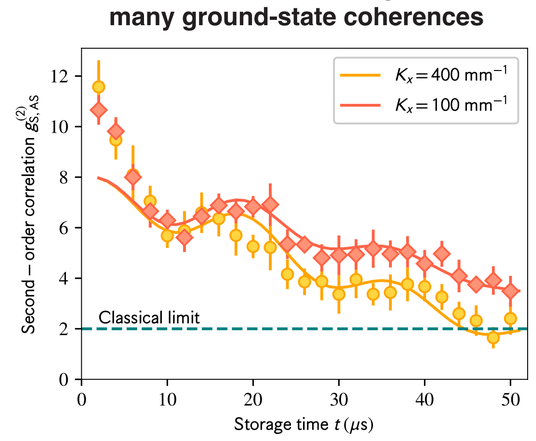
Spatially-resolved analysis of quantum correlations



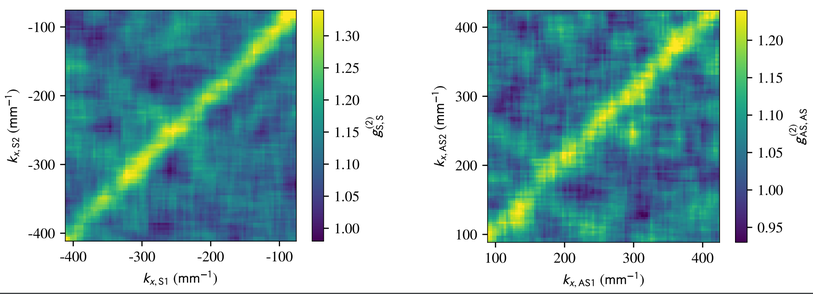
Nonclassical photon-number correlations in 665 modes



Simultaneous storage in many ground-state coherences



Autocorrelations

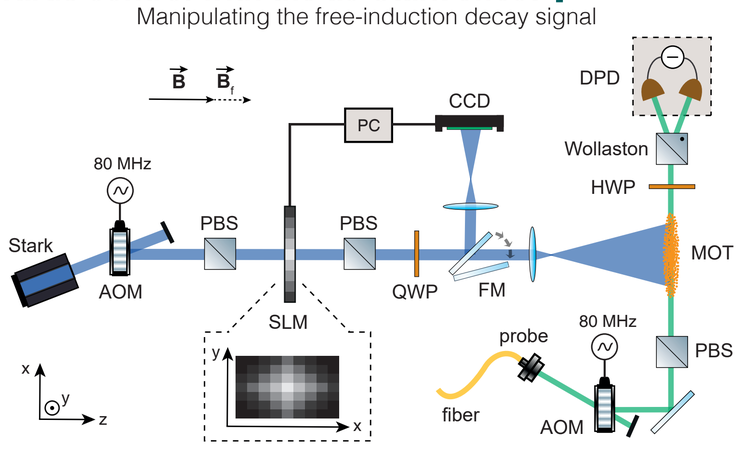


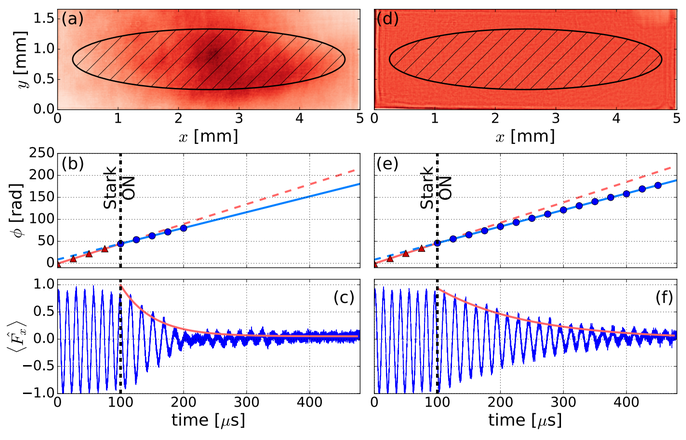
Nonclassicality verifed by violating the Cauchy-Schwarz inequality

$$R = \frac{[g^{(2)}_{S,AS}]^2}{g^{(2)}_{S,S} g^{(2)}_{AS,AS}} \leq 1$$

Towards control with the ac-Stark effect [arXiv:1712.07747]

Manipulating the free-induction decay signal



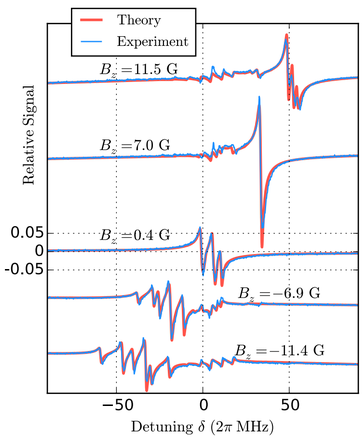


Light-atom interaction effectievly described by vector Hamiltotnian in analogy to magnetic field

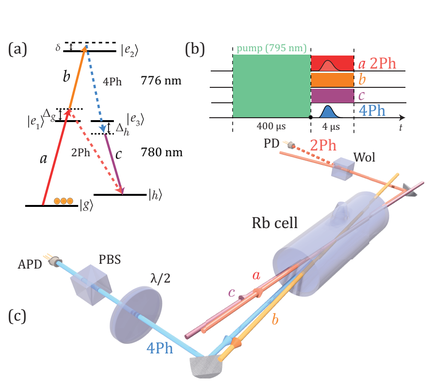
$$\hat{H}_S^{(1)} = g\alpha^{(1)} \hat{S}_z \hat{F}_z$$

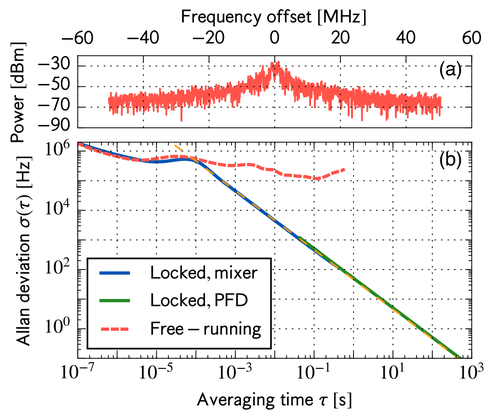
Key parameters

- 665 stored Schmidt modes
- 50 μs storage time and 100 ns write/read time - perfectly matched to live-feedback applications
- camera frame rate of 1000 fps with perspectives to reach 500.000 fps soon
- operation with DFB and ECDL lasers locking to a common frequency reference
- possible interfacing with higher Rb energy levels



[Appl. Phys. Lett. 108, 161103 (2016), PRA 93, 053821 (2016)]





[Appl. Phys. B 123:238, arXiv:1612.00859]

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Warm atoms experiments: PRA 91, 023418 (2015); PRL 118, 063603 (2017); PRA 93, 053821 (2016); OpEx 24, 21995 (2016); J. Mod. Opt. 63, 2039 (2016); APL 108, 161103 (2016); J. Mod. Opt. 63, 2029 (2016); OpEx 25, 284 (2017);
Single-photon resolving I-sCMOS camera experiments: Nat. Photonics 10, 576-579 (2016); Nat. Commun. 7, 11411 (2016).