MULTIMODE SPATIAL PROPERTIES OF THE DELAYED TWIN BEAM GENERATOR

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INTRODUCTION

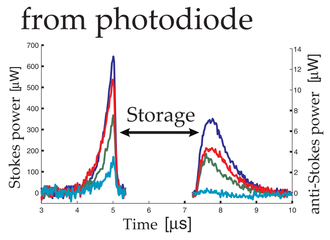
PROCESS
Raman scattering in warm Rubidium vapors - the medium with the memory.

ADVANTAGE
Adjustable delay time between twin beams.

APPLICATION
In the future: long distance quantum communication
Now: controllable source of narrowband quantum light

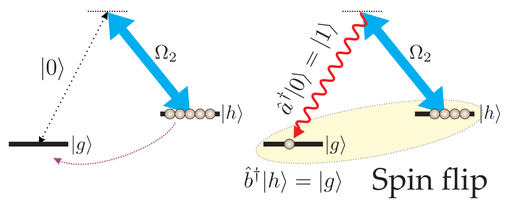
OBJECTIVE
Characterization of the spatial multimode performance of the generator.

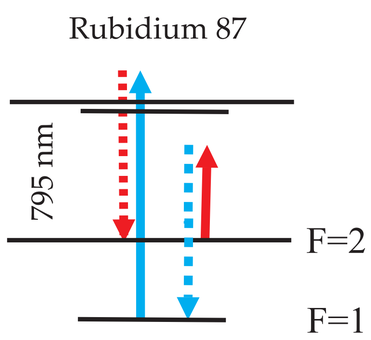
Integrated signal from photodiode



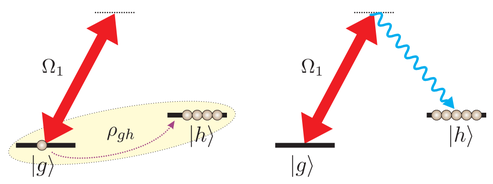
RAMAN SCATTERING IN ATOMIC ENSEMBLES

WRITE
Stokes scattering





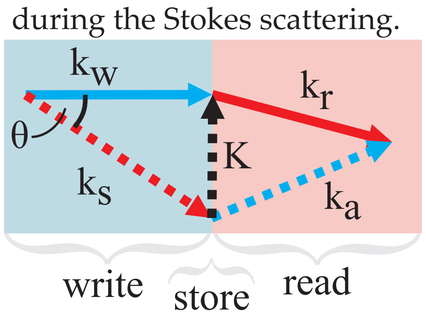
READ
anti-Stokes scattering



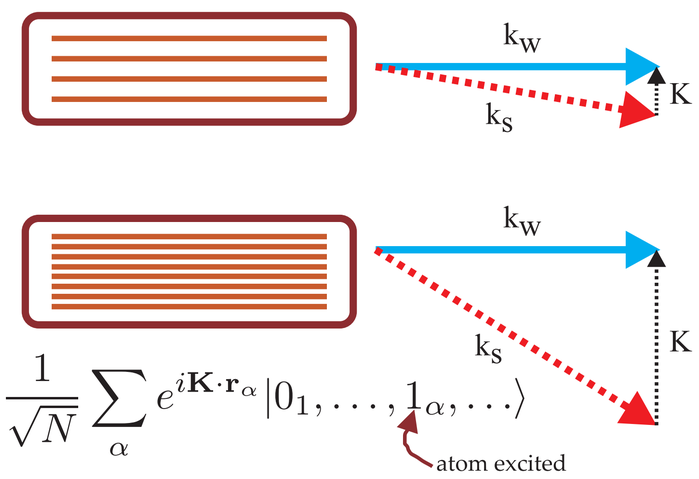
Conversion: atomic excitation to light

COLLECTIVE EXCITATIONS - SPIN-WAVES

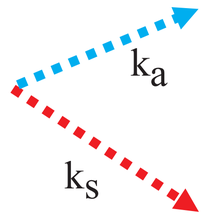
Momentum transfer to medium during the Stokes scattering.



Momentum retrieval in the anti-Stokes scattering.

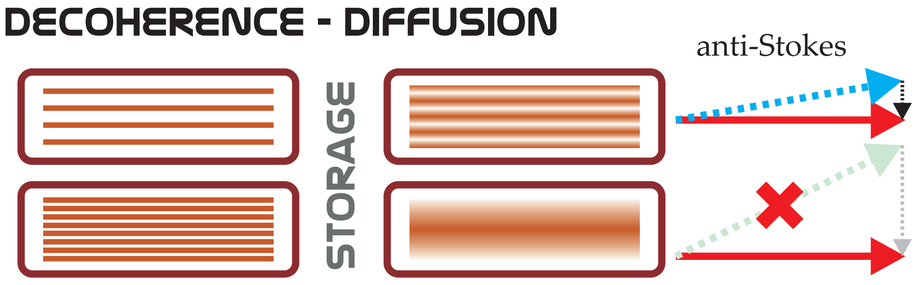


Spatially correlated twin beams



High angles of scattering = high momentum transferred and the dense periodicity of the created spin-wave.

DECOHERENCE - DIFFUSION



spin-wave creation

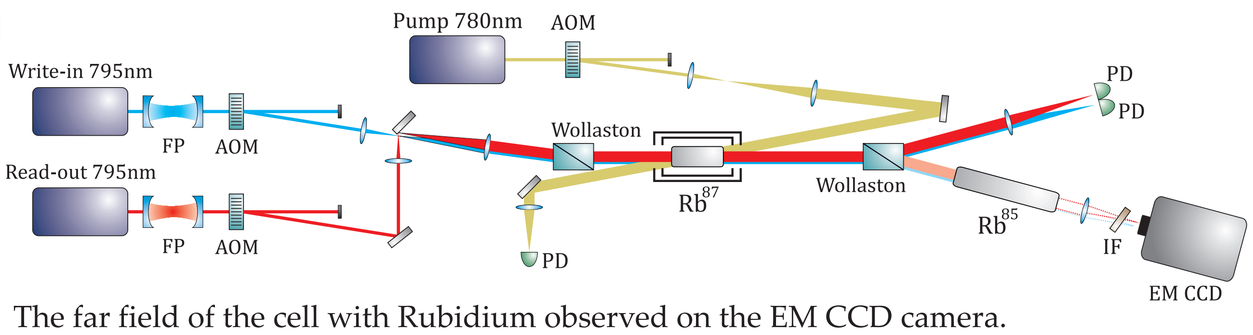
atoms move due to diffusion

high **K** cannot be retrieved

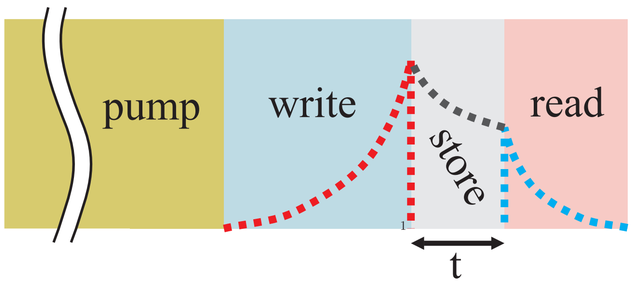
The higher angle of scattering:
- the lower Raman gain
- the shorter spin-wave storage time

We use buffer gas: Krypton or Neon to slow down the diffusion

EXPERIMENTAL SETUP

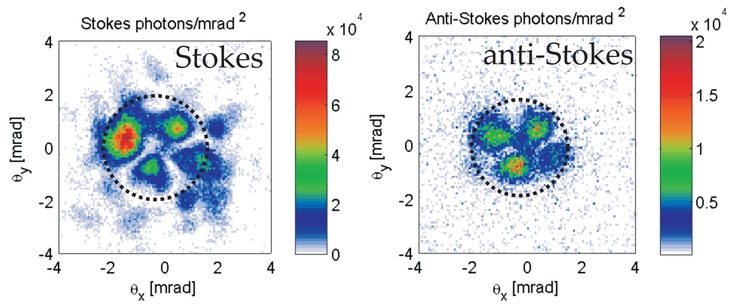


The far field of the cell with Rubidium observed on the EM CCD camera.
Spatial dimensions of the sensor calibrated to angles of scattering.

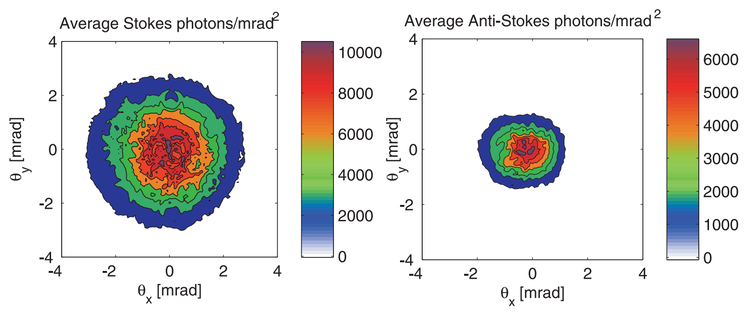


Pulse sequence starts with the optical pumping

IMAGES FROM THE CAMERA



Single shot image - speckle-like diffraction random picture. Within the retrieval region (circle) each spot has its counterpart in the anti-Stokes region.

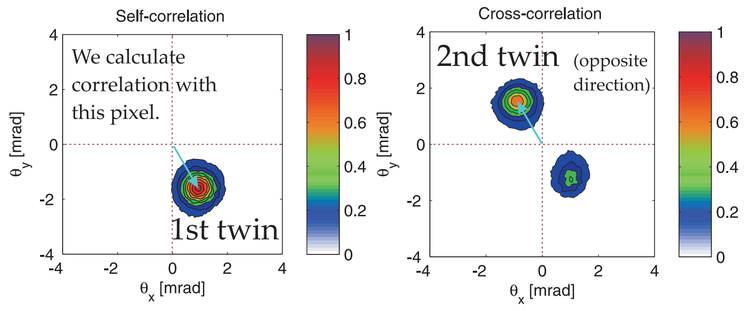


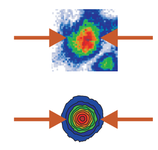
Average over 10k frames with random patterns like above, shows the symmetric scattering distribution

TWIN BEAMS

$$C(\theta,\theta') = \frac{\langle \Delta n_s(\theta)\Delta n_a(\theta')\rangle}{\sqrt{\langle \Delta n_s^2(\theta)\rangle\langle \Delta n_a^2(\theta')\rangle}}$$

Intensity correlations map of the one pixel

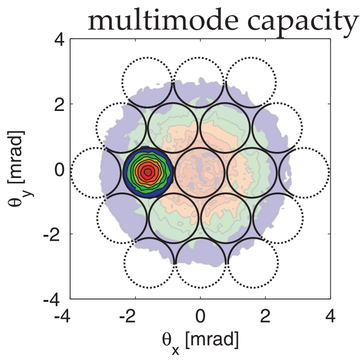




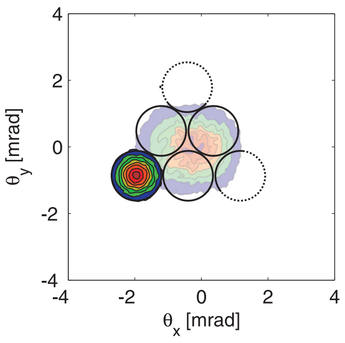
The correlation size (the **k**-vector spread) the same as for the single shot spot.

MULTIMODE CAPACITY

Correlation size vs. the average = estimated multimode capacity



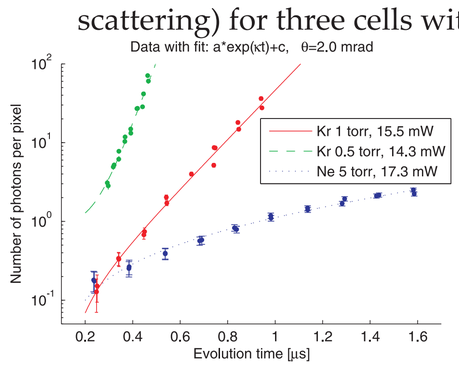
~10 modes excited



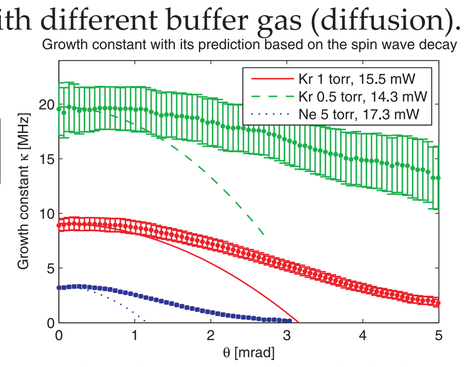
~3 modes retrieved - strong decoherence influence

PERFORMANCE OF THE GENERATOR

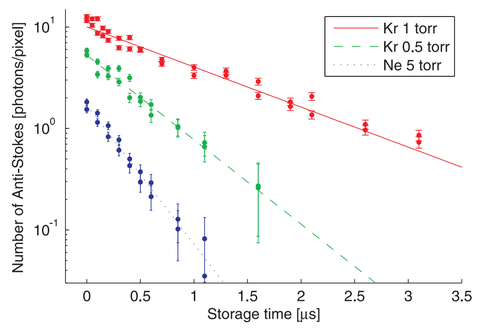
We track the average evolution of a single pixel (specific angle of scattering) for three cells with different buffer gas (diffusion).



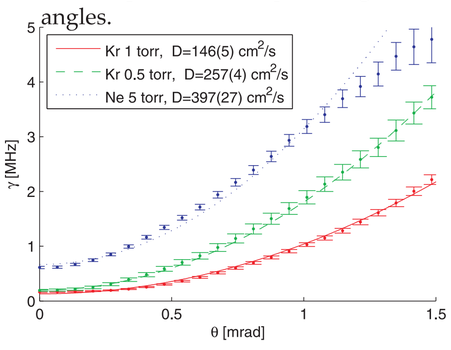
Stokes scattering growths exponentially.



Growth parameter drops for high angles.



The exponential decay of the anti-Stokes scattering vs. storage time.



The decay growths quadratically due to diffusion. The best performance for 1 torr of Krypton.

INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

FNP
Foundation for Polish Science

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND