Shadow Imaging using Quantum-Noise Detection with a Camera

Eugeniy E. Mikhailov, Savannah Cuozzo, Nikunjkumar Prajapati, Irina Novikova[1]
Pratik J. Barge, Narayan Bhusal, Hwang Lee, Lior Cohen, and Jon Dowling[2]

1

WILLIAM & MARY
CHARTERED 1693

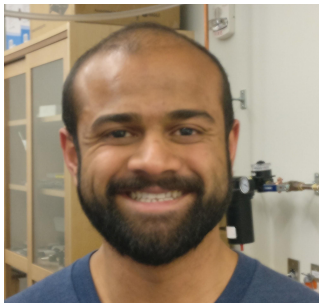
2

People

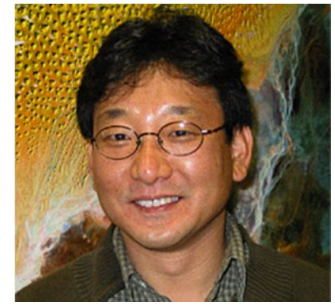

Savannah Cuozzo


Irina Novikova

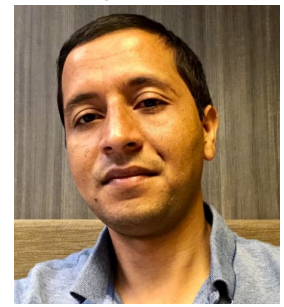

Jon Dowling (1955-2020)


Nikunjkumar Prajapati

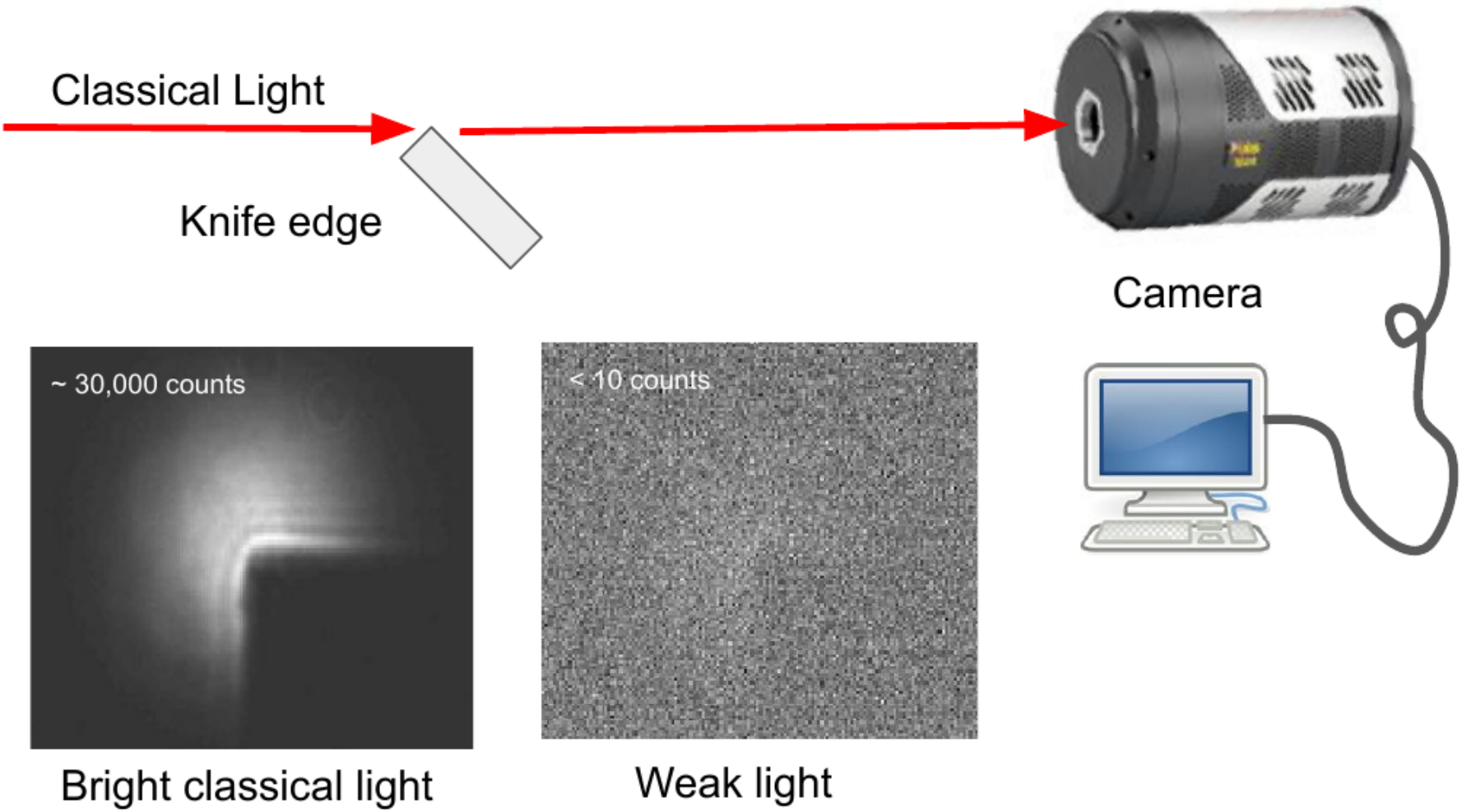

Lior Cohen


Hwang Lee

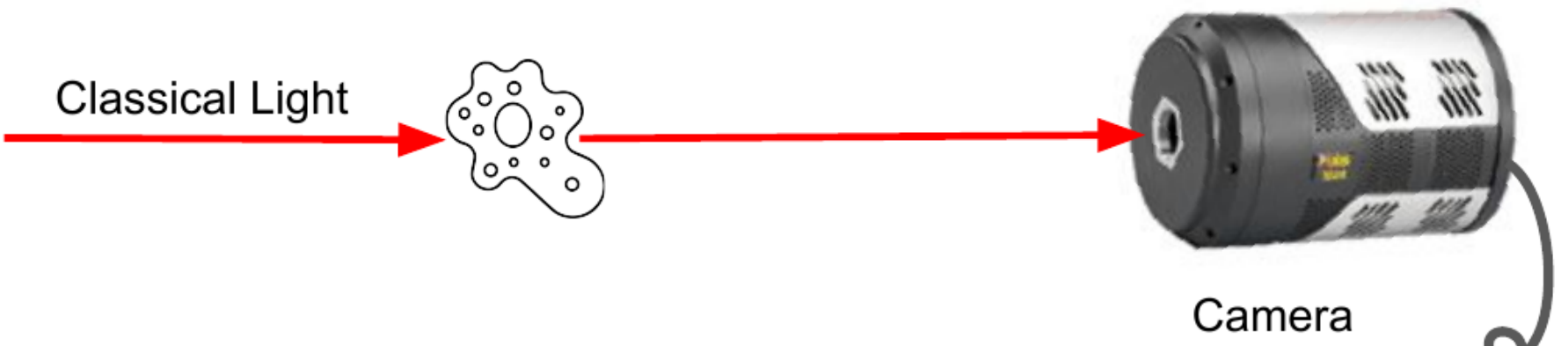

Pratik Barge

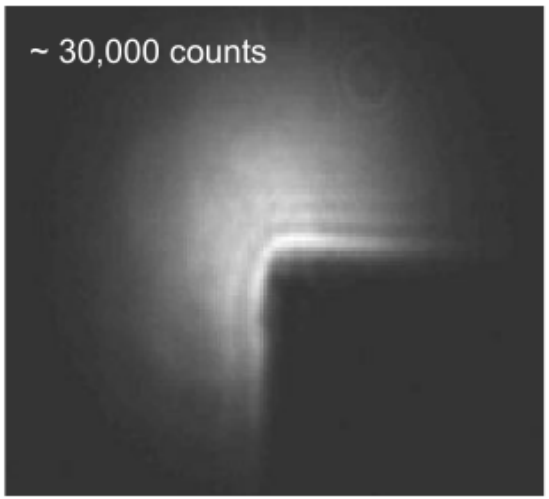

Narayan Bhusal

From bright to low light imaging

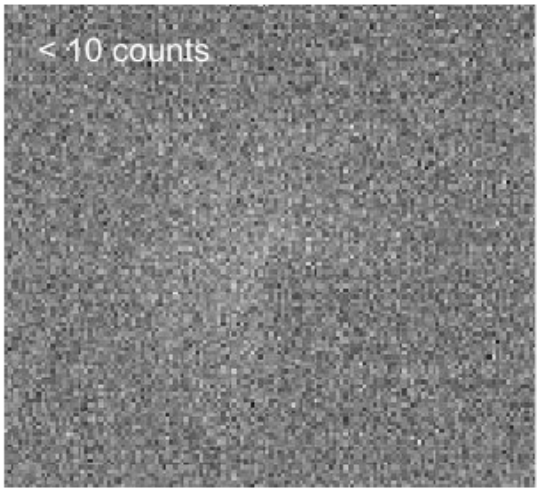


From bright to low light imaging





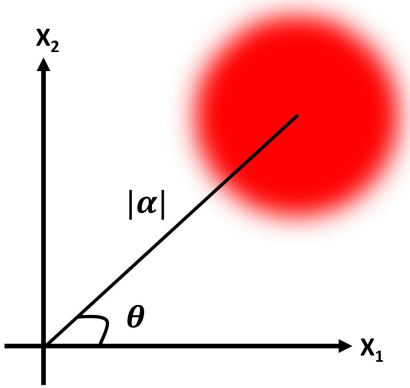
Bright classical light



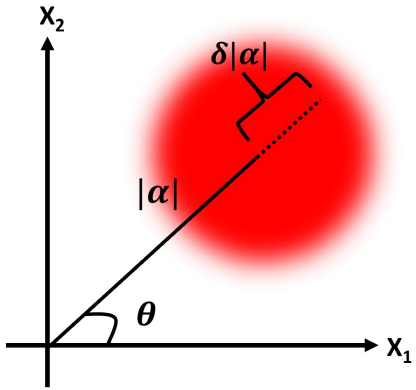
Weak light

Let's look at quantum picture

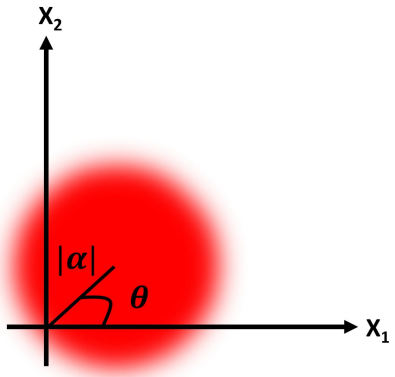
Bright state in



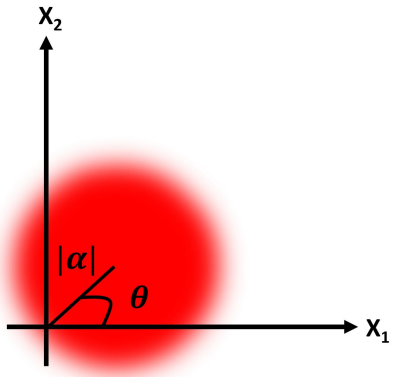
Bright state out



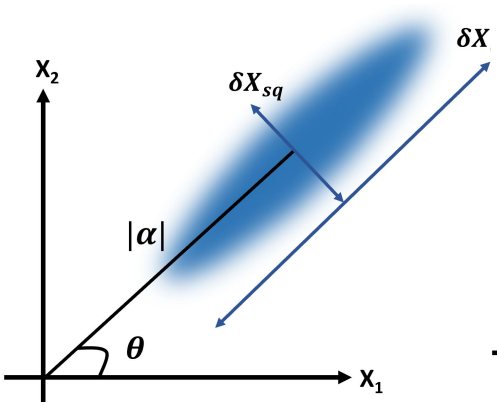
Low-light state in

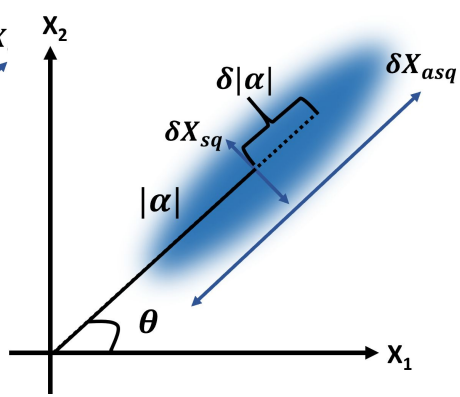


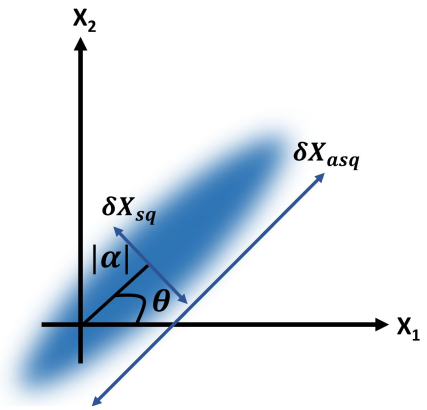
Low-light out

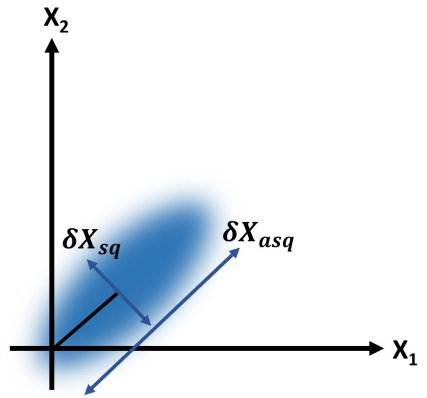


$$\alpha_{out}^2 = \alpha_{in}^2 T$$



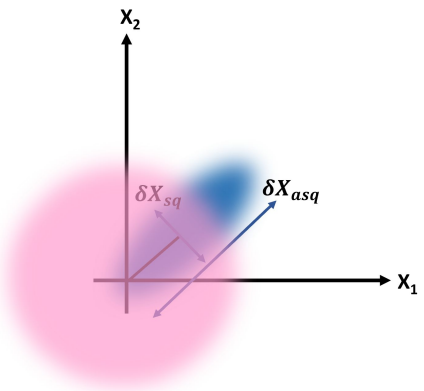




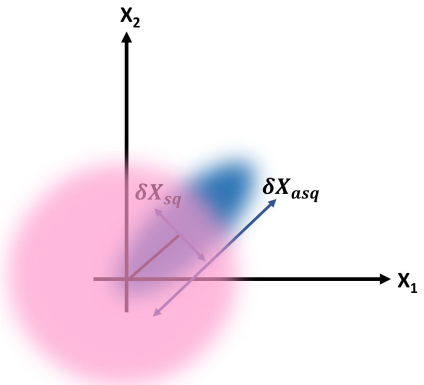


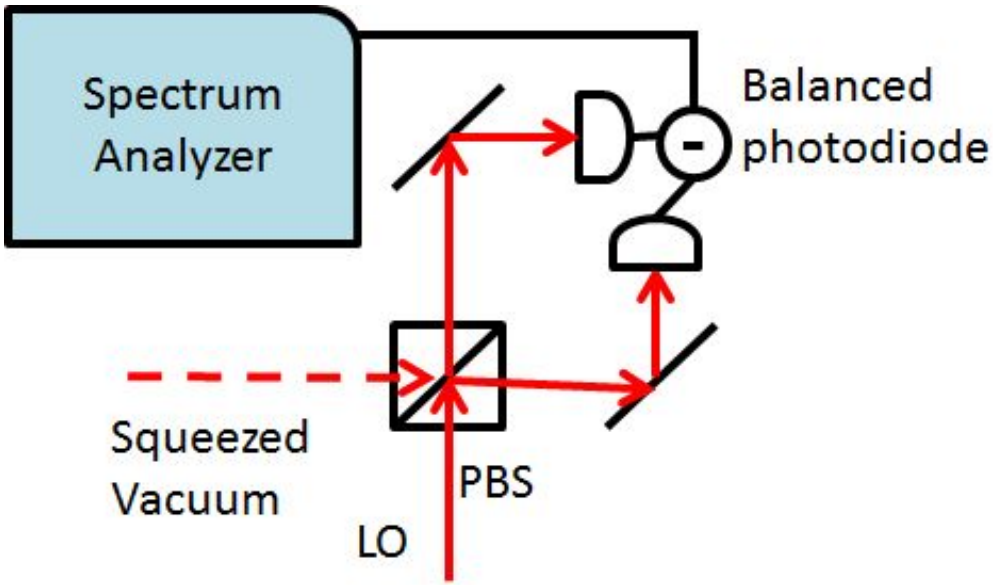
$$V = 1 + (\delta X_{sq/asq}^2 - 1)\mathcal{O}T$$

Detector dark noise

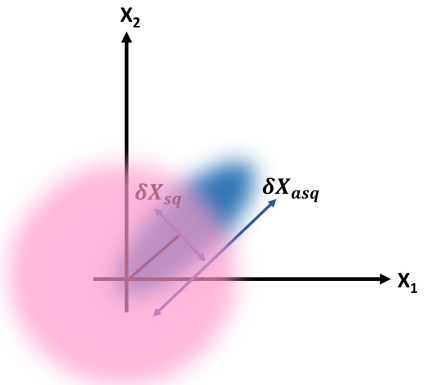


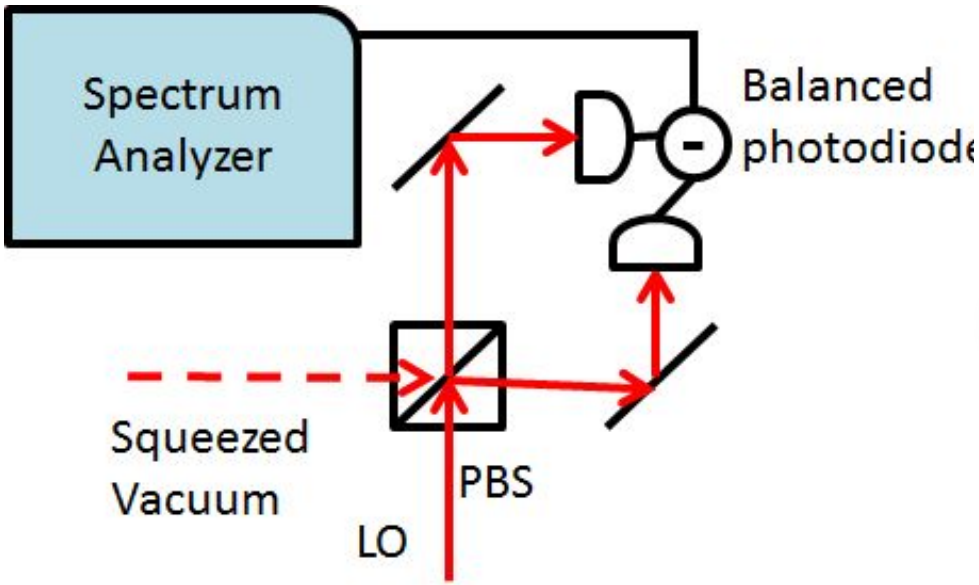
Detector dark noise

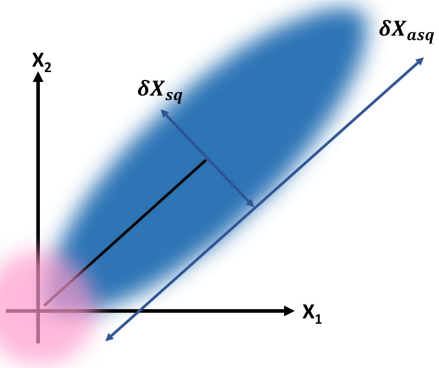




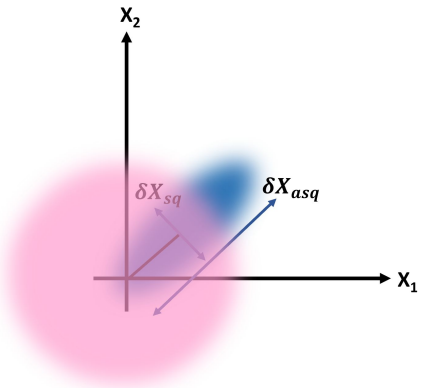
Detector dark noise

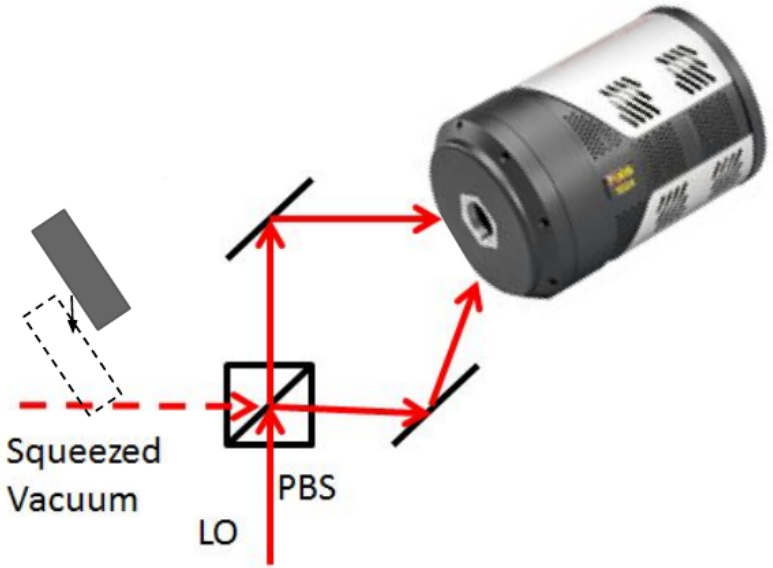


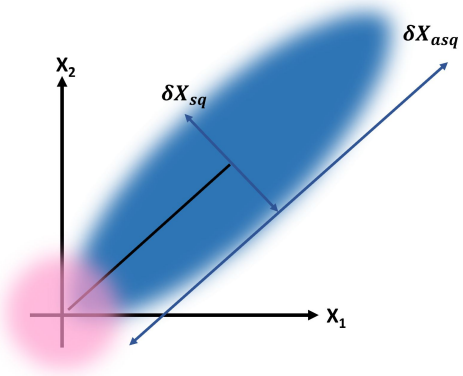




Detector dark noise

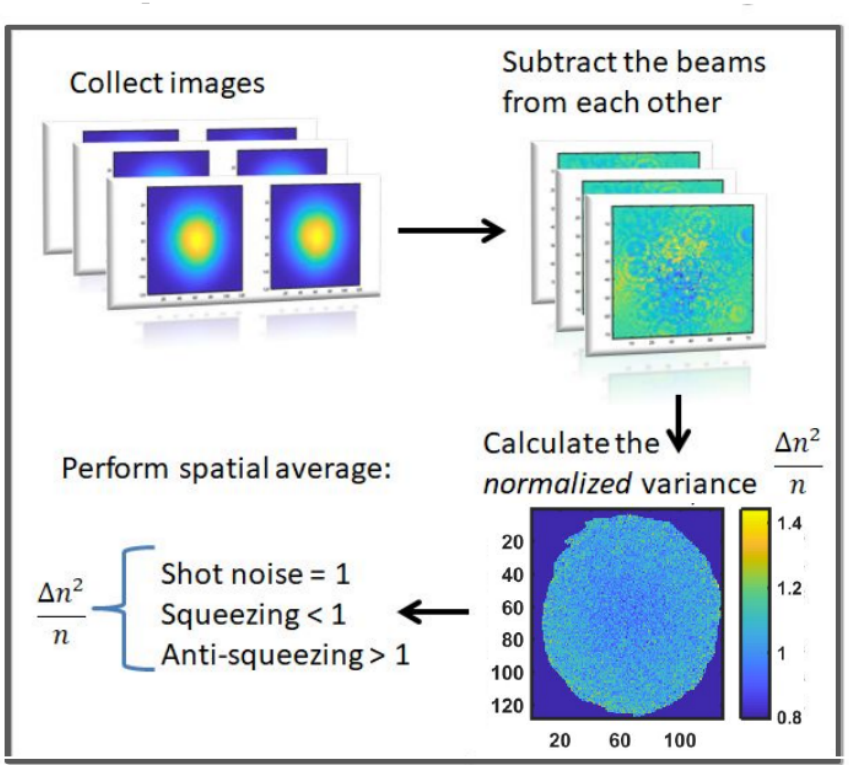


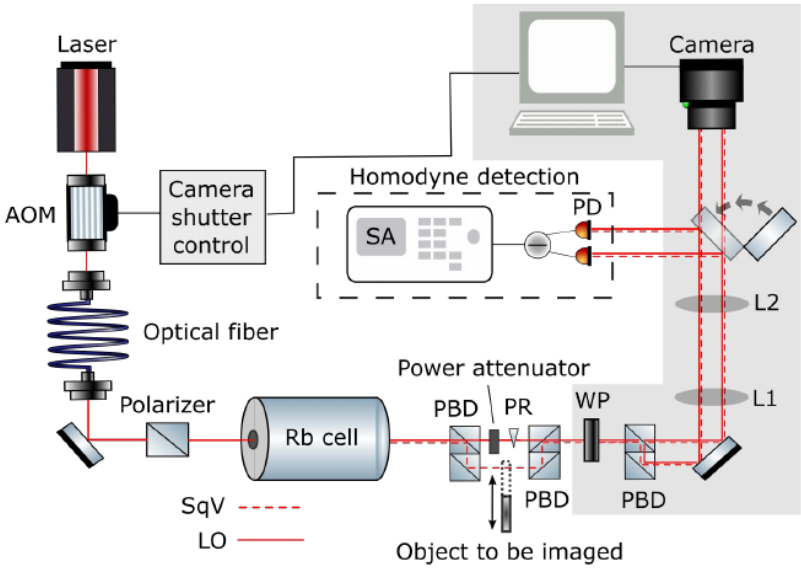




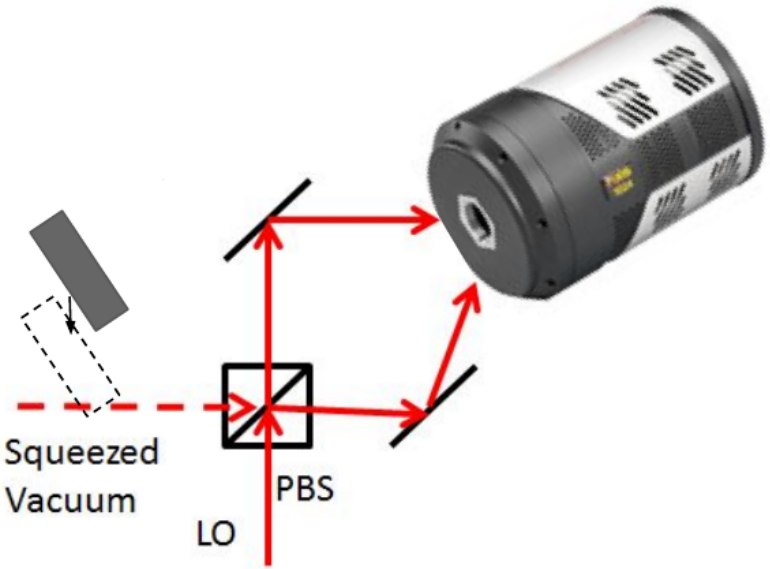
"Quantum-Limited Squeezed Light Detection with a Camera", Phys. Rev. Lett. **125**, 113602

Imaging quantum noise



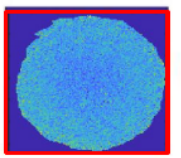


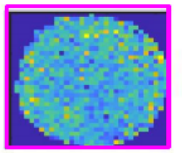
Imaging quantum noise with binning

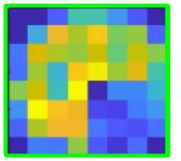


$$V = 1 + (\delta X^2_{sq/asq} - 1)\mathcal{O}T$$

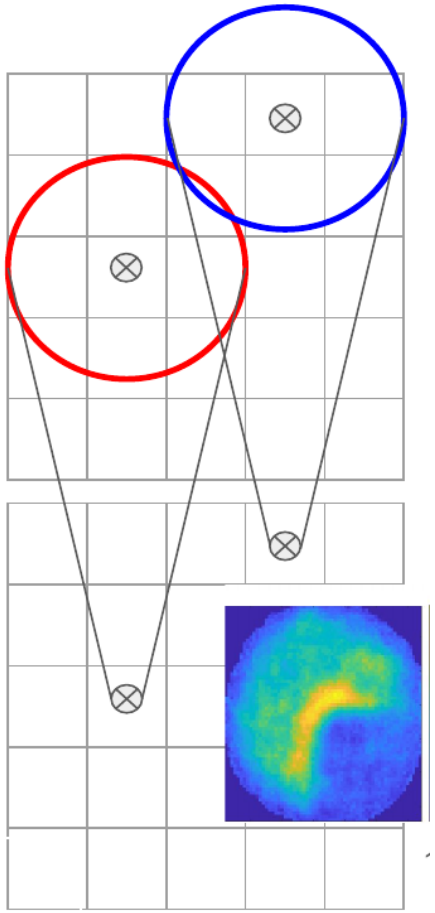
- Single pixel analysis = shot noise limited


Binning = 1

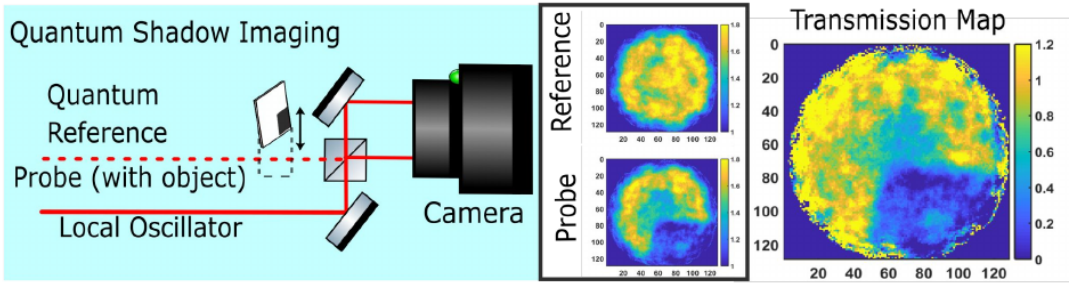

Binning = 4

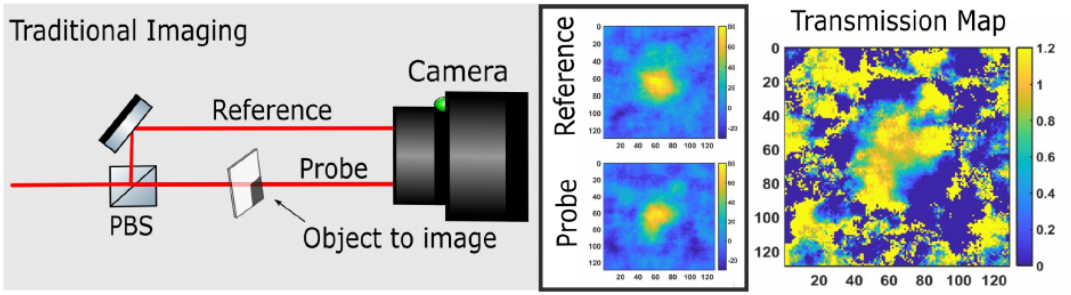

Binning = 16

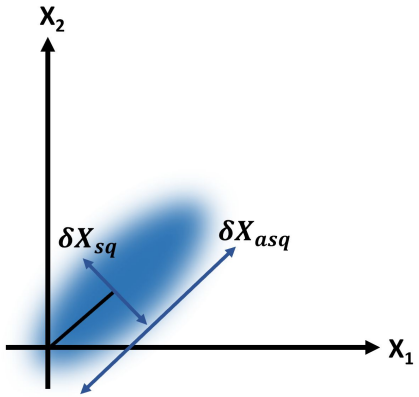
- Binning pixels reveals non-classical statistics



Shadow imaging





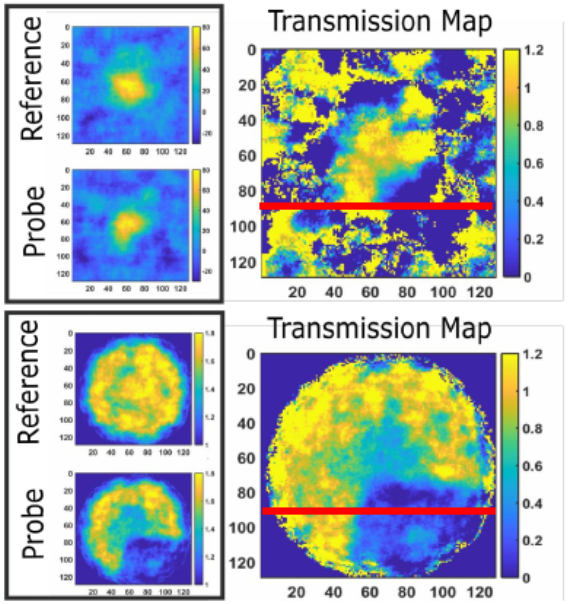


$$V_{pr} = 1 + (\delta X_{ref}^2 - 1)\mathcal{O}T$$

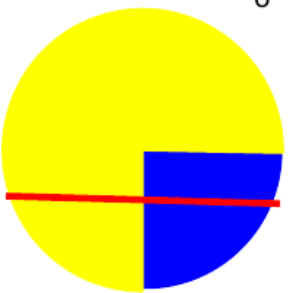
$$T = \frac{V_{pr} - 1}{V_{ref} - 1}$$

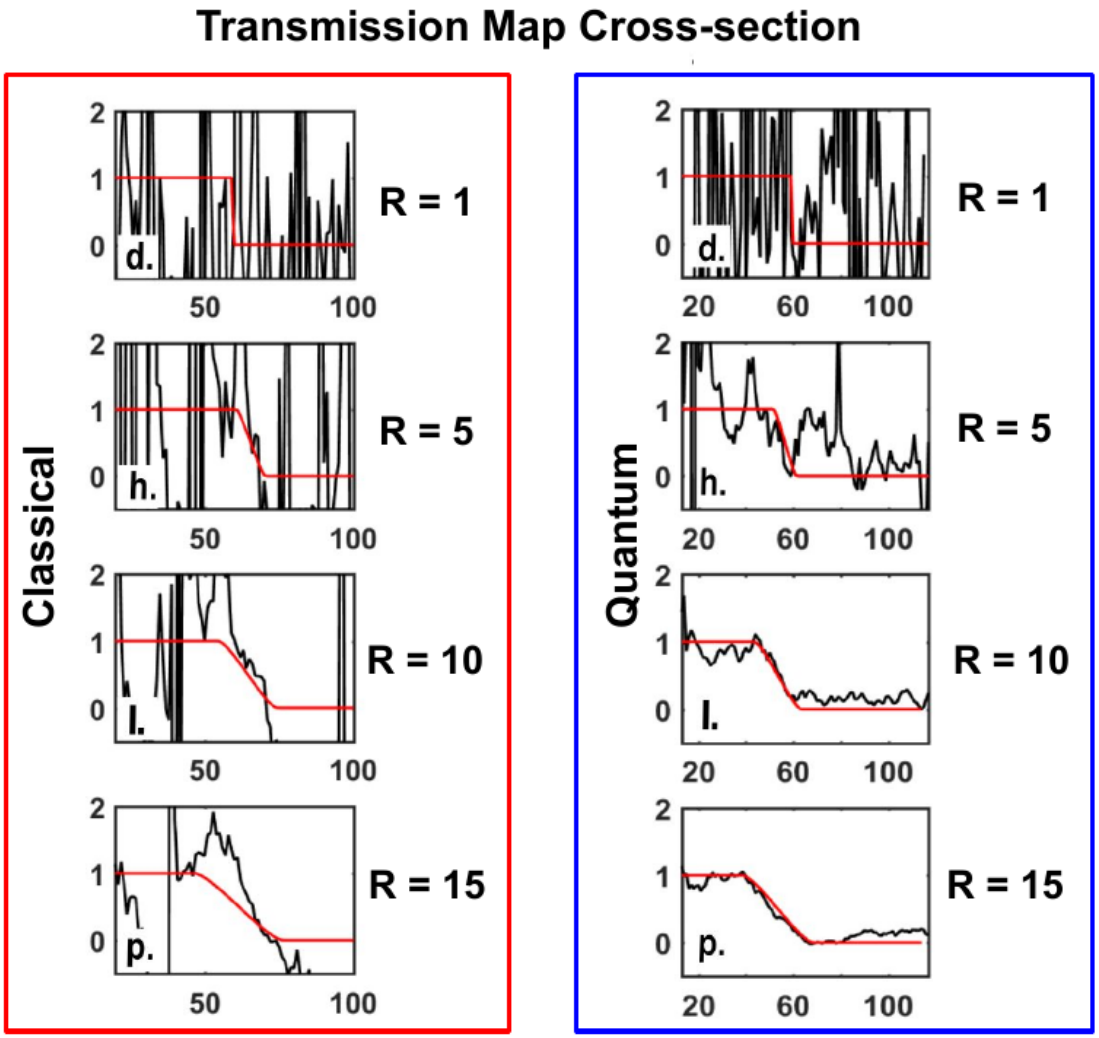
$$T = \frac{|\alpha_{pr}|^2}{|\alpha_{ref}|^2} = \frac{N_{pr}}{N_{ref}}$$

Similarity Parameter



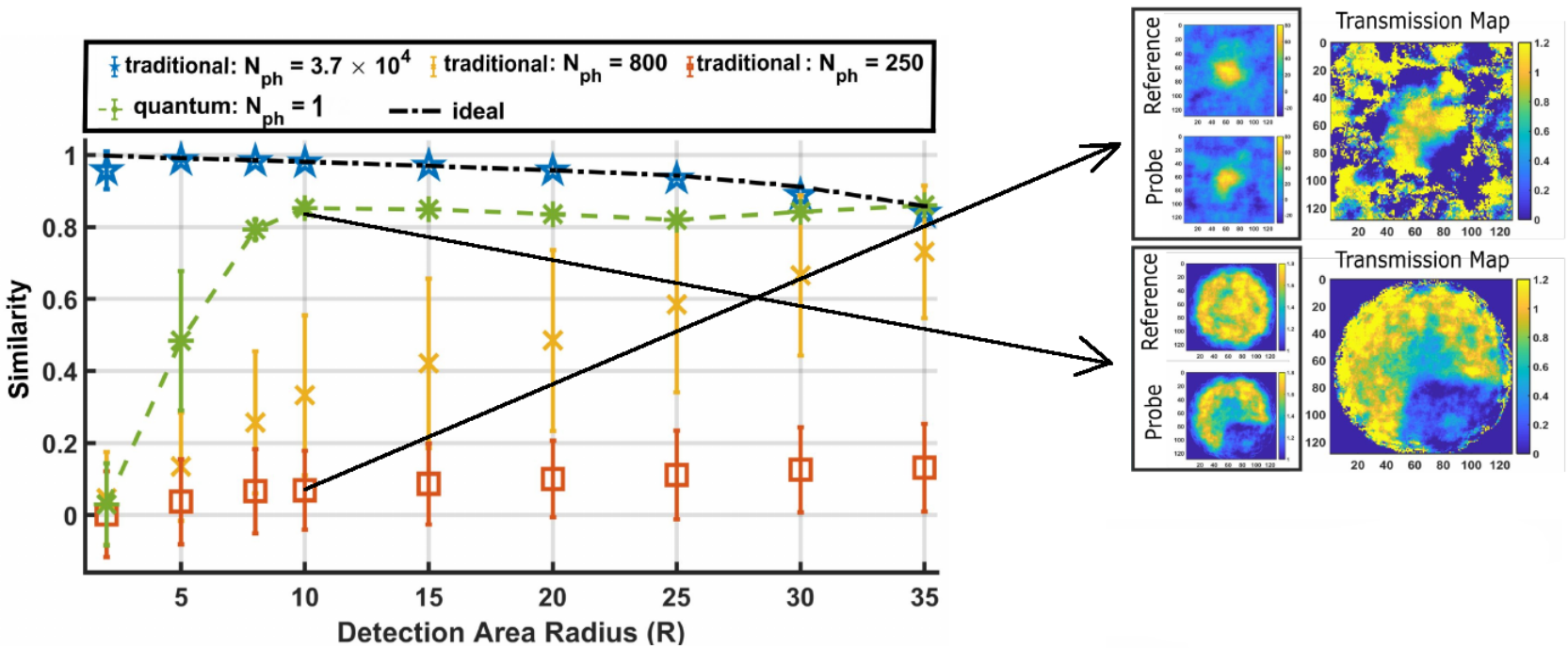
Ideal case: T_o





$$S = \frac{\sum T_{exp} T_o}{\sqrt{\sum T_{exp}^2 \sum T_o^2}}$$

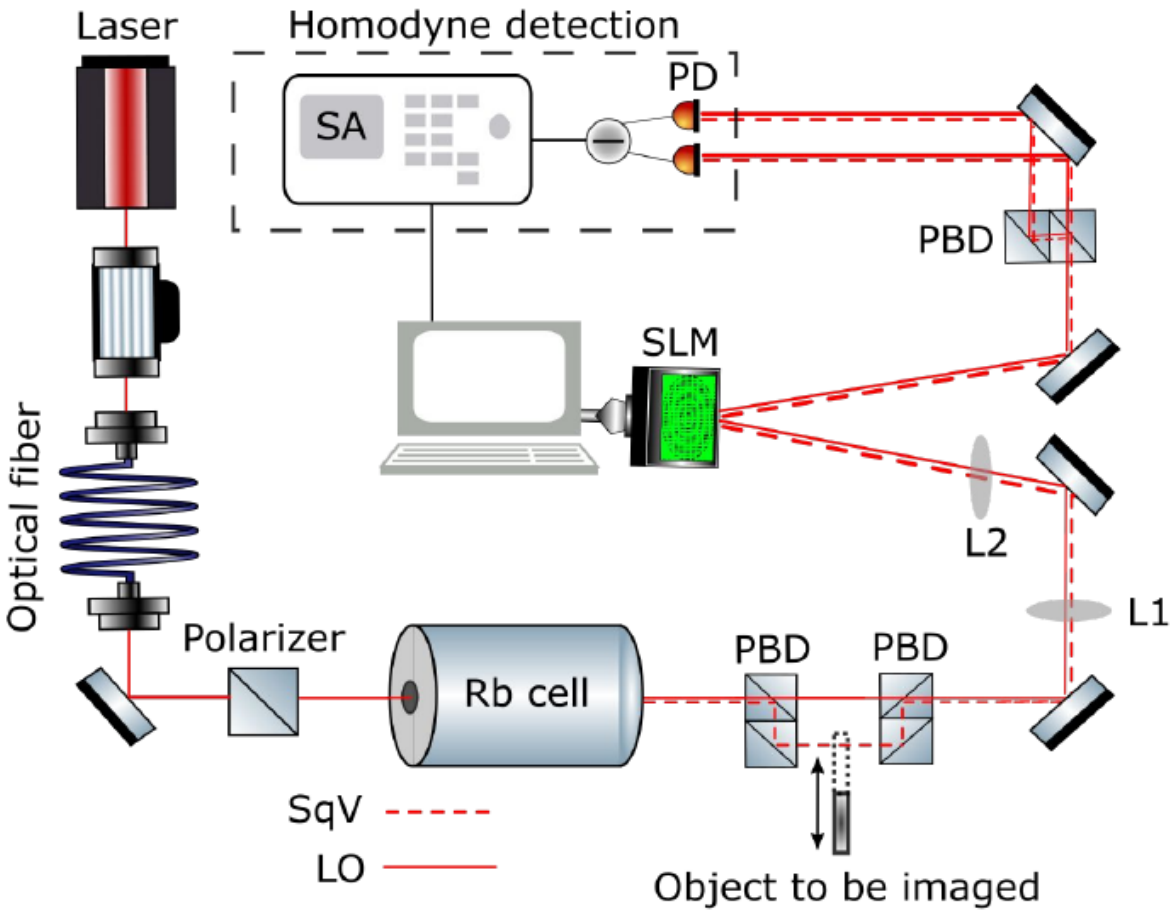
Similarity Parameter

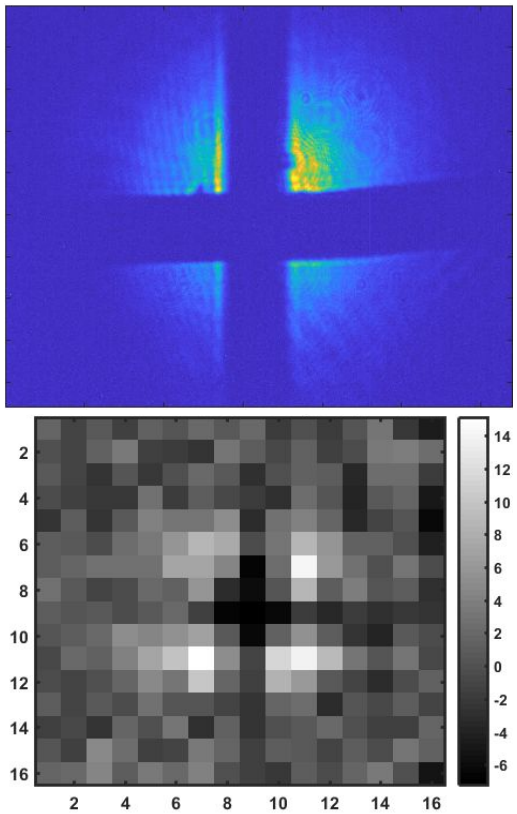


$$S = \frac{\sum T_{exp} T_o}{\sqrt{\sum T_{exp}^2 \sum T_o^2}}$$

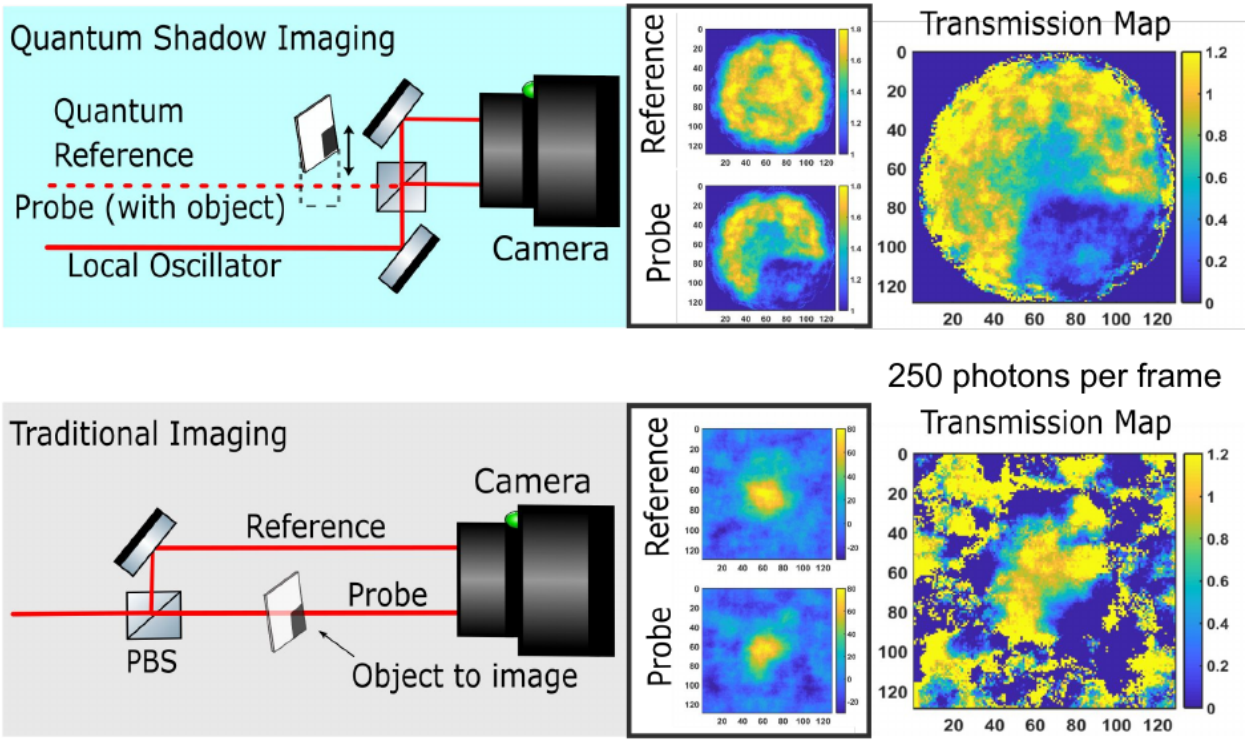
"Low-Light Shadow Imaging using Quantum-Noise Detection with a Camera" https://arxiv.org/abs/2106.00785

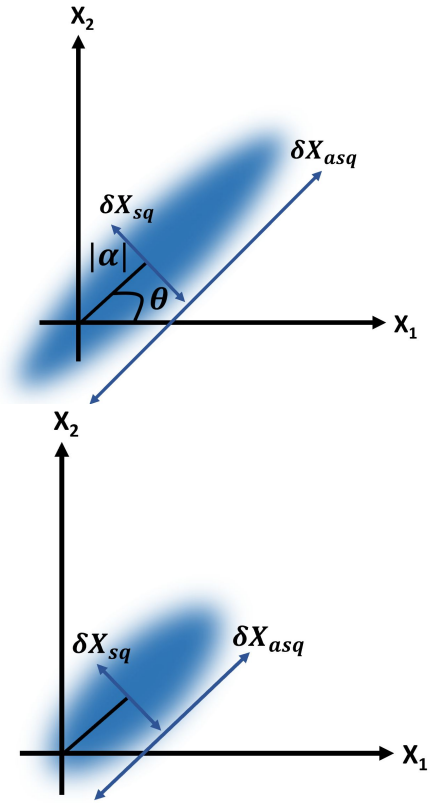
Structural light imaging with quantum noise: no camera needed





Summary





"Low-Light Shadow Imaging using Quantum-Noise Detection with a Camera" https://arxiv.org/abs/2106.00785