Conditional preparation of non-Gaussian quantum optical states by mesoscopic measurement

Alex O.C. Davis[a*], Mattia Walschaers[a], Paul Renault[a], Ganael Roeland[a], Thibault Michel[a], Valentina Parigi[a], Nicolas Treps[a]

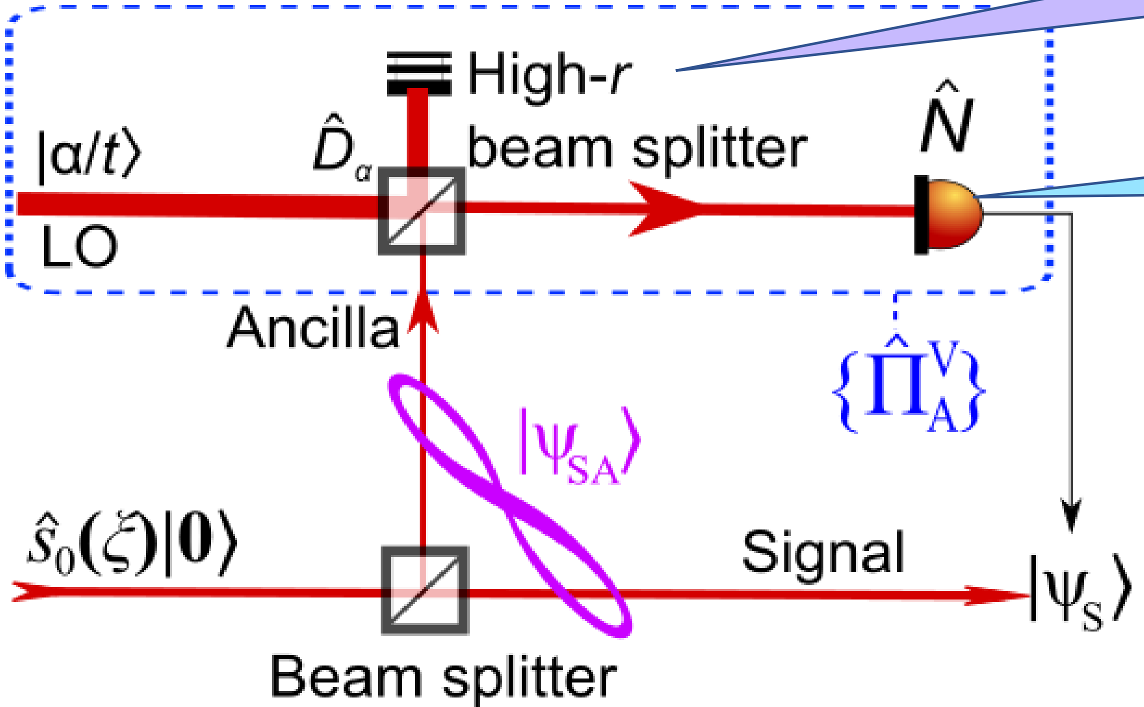
[a]Laboratoire Kastler-Brossel, UPMC-Sorbonne Universités, CNRS, ENS-PSL Research University, Collége de France, 75005 Paris, France

*alex.davis@lkb.upmc.fr

Non-Gaussian states are a resource for quantum information applications (e.g preparing GKP states)

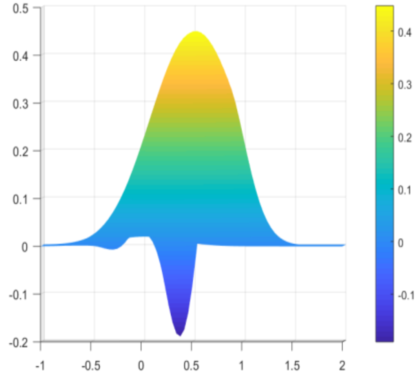
Conditional preparation: Entangled Gaussian state $|\psi_{SA}\rangle$ prepared

Ancilla undergoes non-Gaussian measurement → Projects signal $|\psi_S\rangle$ into non-Gaussian state



Displacing ancilla allows use of higher-intensity ("mesoscopic") detector

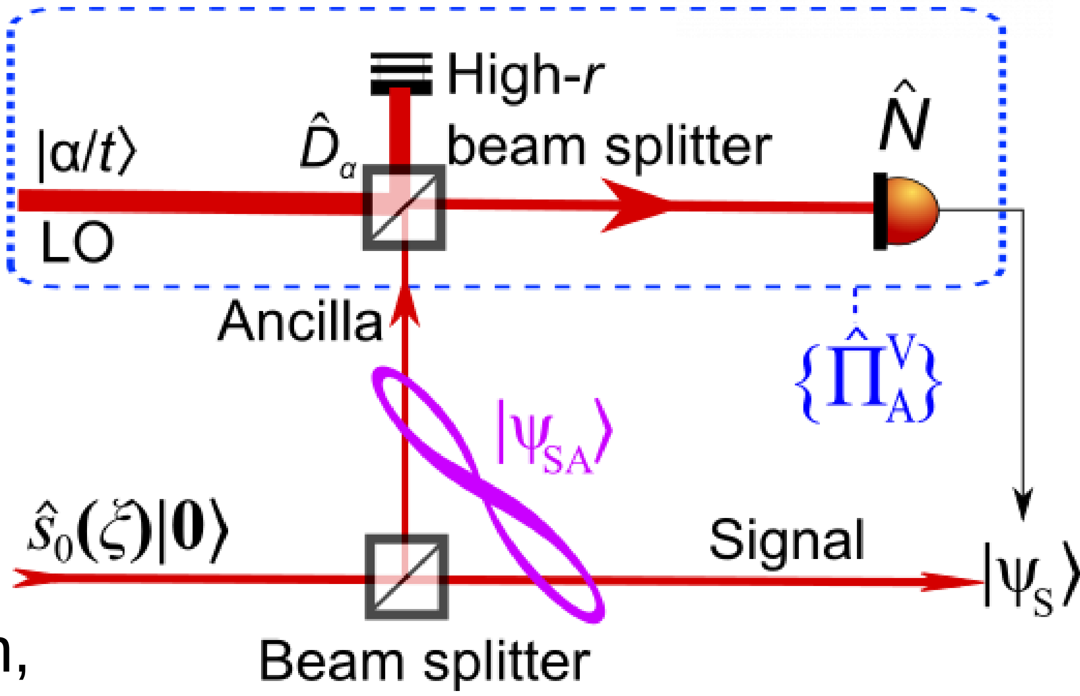
No dead time; high BW; wide dynamic range; good QE

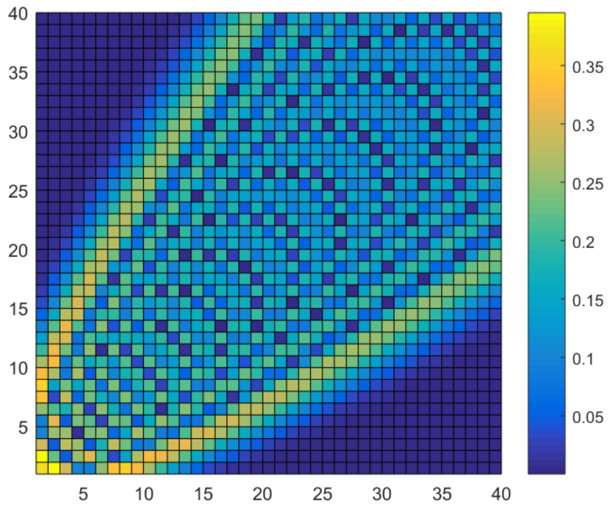


Non-Gaussianity robust to imperfect detection

Conditional preparation

- Non-Gaussian/Wigner-negative states valuable as quantum information resource
- Conditional preparation: Non-Gaussian measurement on Gaussian-entangled subsystem → generates non-Gaussian state
- SPCMs have issues: dead time, saturation, max. count rate, quantum efficiency, operating temp…
- By displacing the ancilla, perform measurements on displaced Fock basis $\widehat{D}(\alpha)|n\rangle$



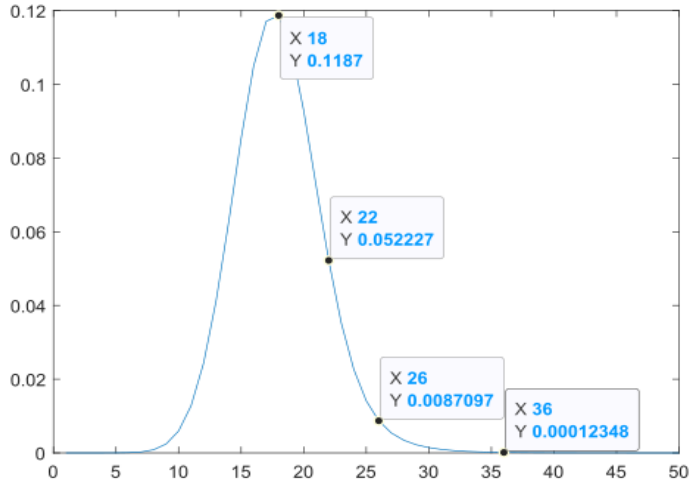


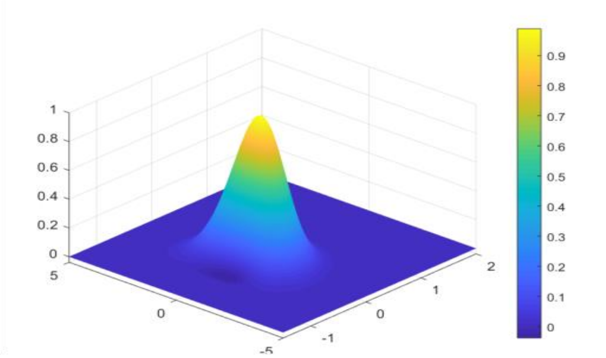
Displaced Fock state measurement

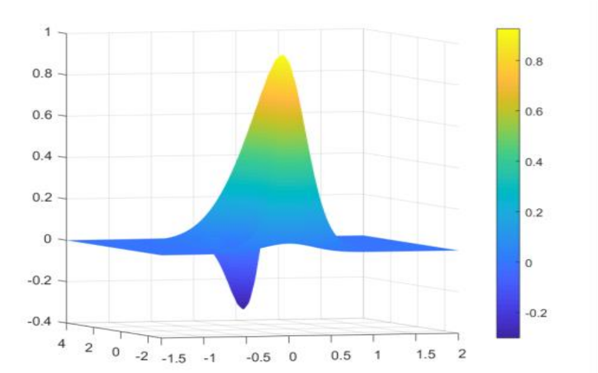
- Without displacement, this scheme generates Schrodinger cat states* but ideal photon counting is necessary

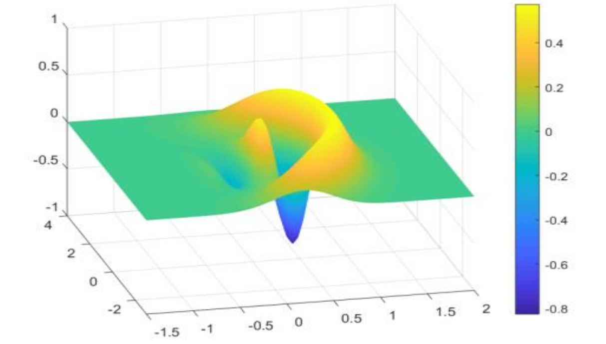
- With displacement, off-by-one errors in counting still herald non-Gaussian states

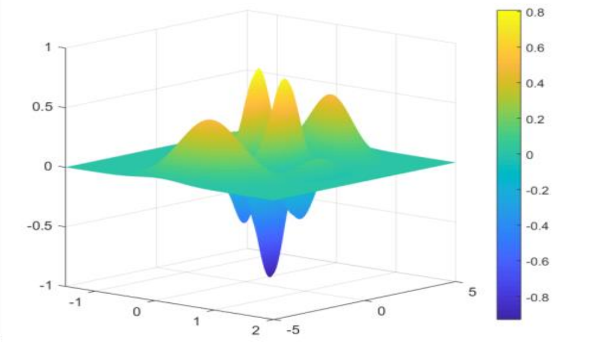
- Conditioned state is highly dependent on phase of displacement field

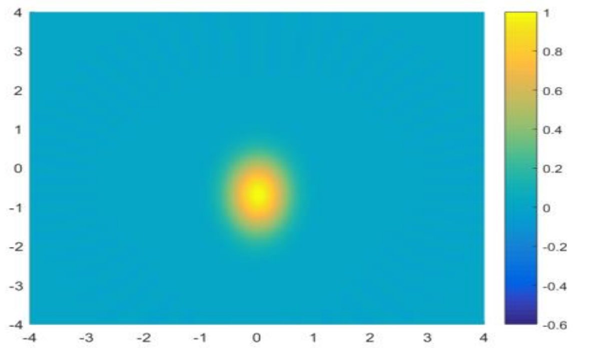


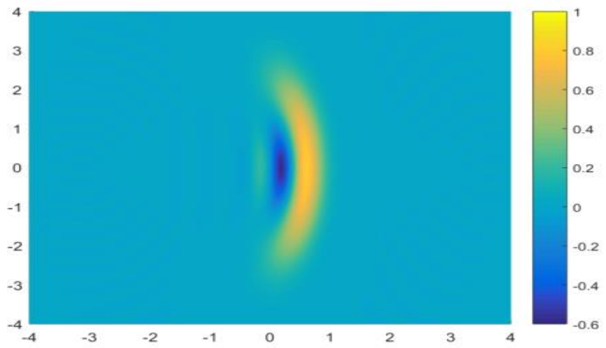








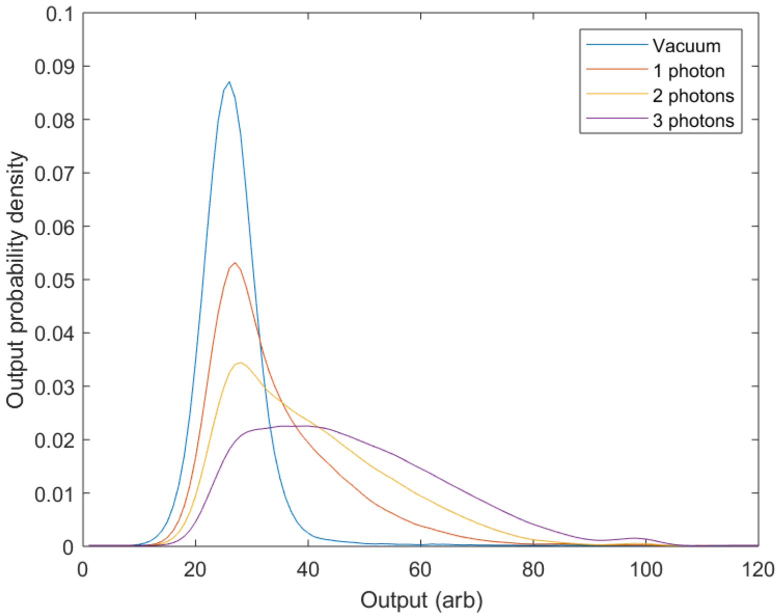


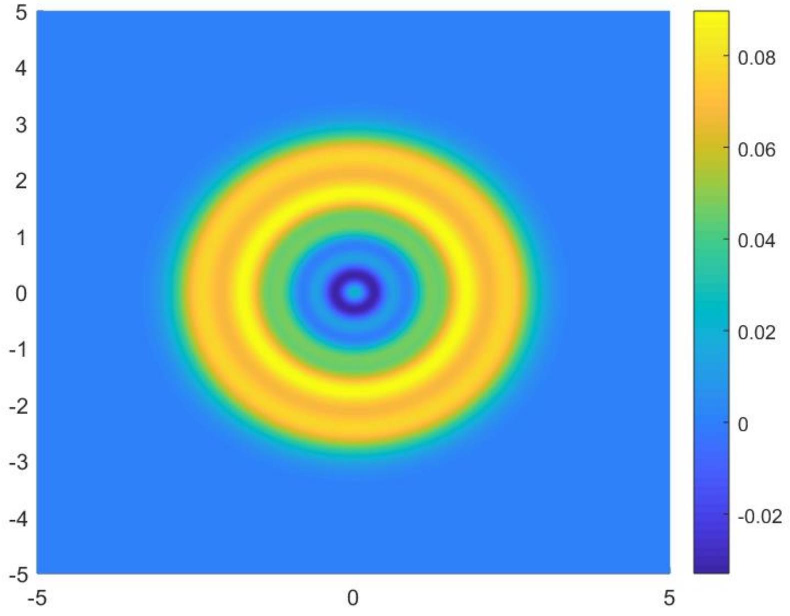


*M. Dakna, T. Anhut, T. Opatrný, L. Knöll, and D.-G. Welsch, Phys. Rev. A 55, 3184 (1997).

Mesoscopic detectors

- Mesoscopic detectors: Quantum receivers (Wigner-negative POVMs) without precise number-resolving capability
- Here consider HgCdTe detectors: No dead time, high BW ~*O*(100 MHz), potential QE > 90%, broad dynamic range, high operating temp (> -196ºC)
- Wigner-negative POVM elements → detectors are quantum receivers





Conclusions

LKB

- Highly non-Gaussian/Wigner-negative states can be heralded by displacement + mesoscopic-level detection

- Non-Gaussianity strongest with particular choice of phase of displacement field

- Ideal photon counting not necessary to herald deep Wigner negativity → robust to imperfect/lossy detectors

- Candidate detector shown to be a quantum receiver in preliminary tomography