

Extraction of non-classical light by interference

Radim Filip

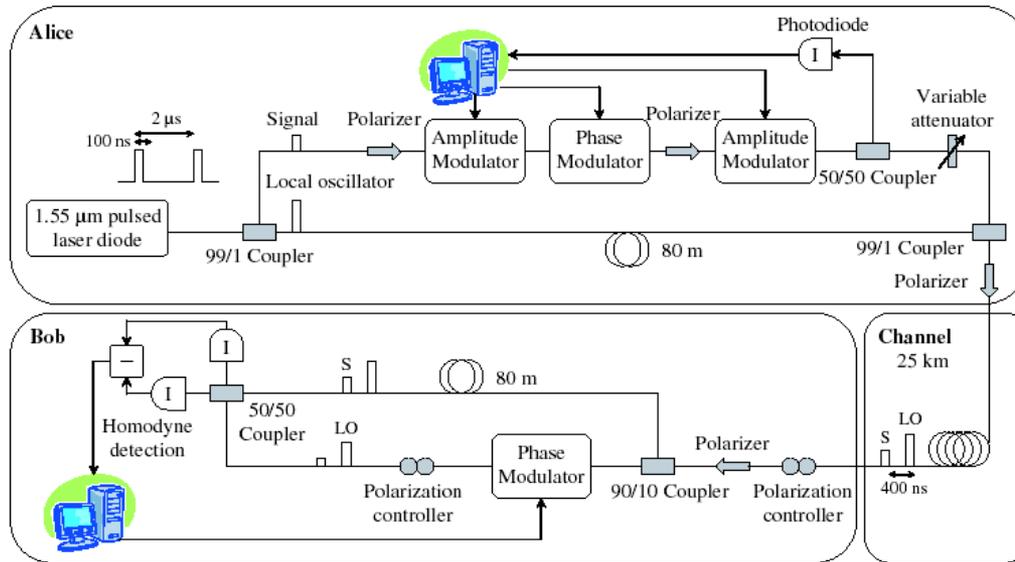
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KEY DISTRIBUTION WITH COHERENT STATES

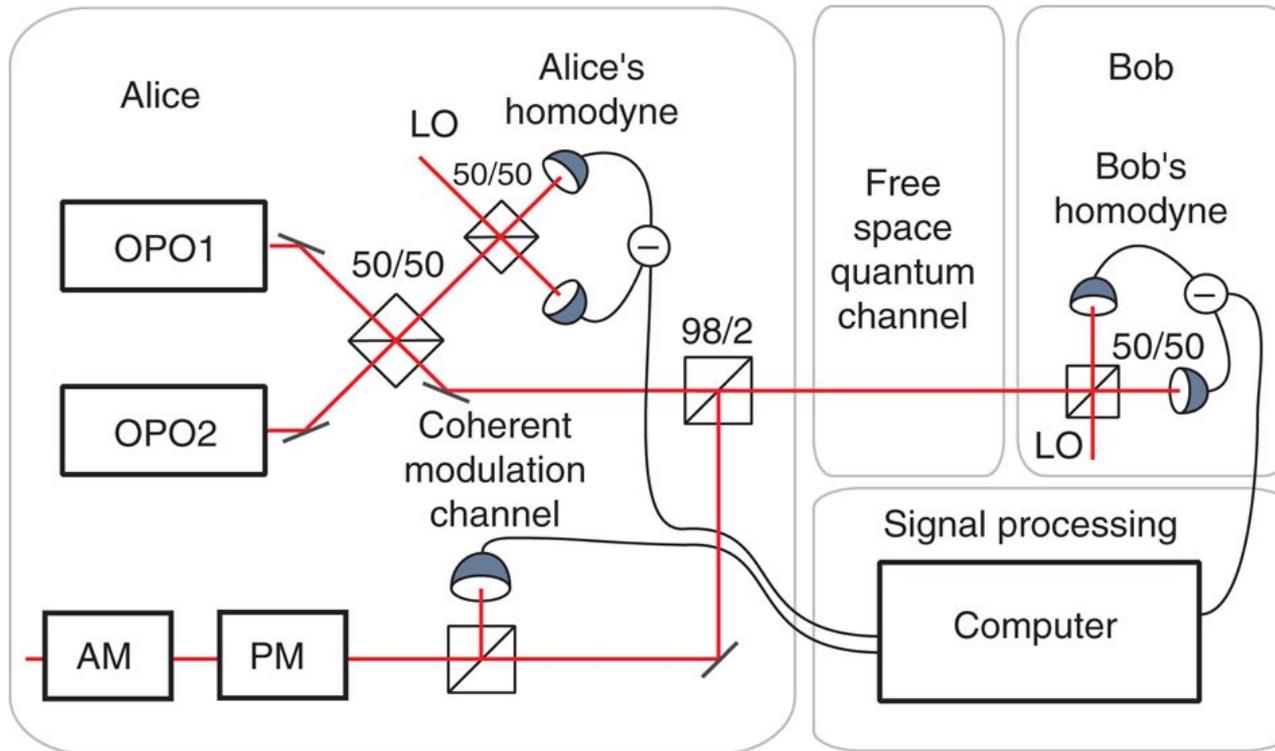


F. Grosshans, G. Van Assche, J. Wenger, R. Brouri, N. J. Cerf, Ph. Grangier, Nature 421, 238 (2003).

Coherent states and homodyne detectors are **sufficient** resources to transmit secure key (for efficient data processing).

Security analysis considers virtual **entanglement**

ENTANGLED STATE CV QKD



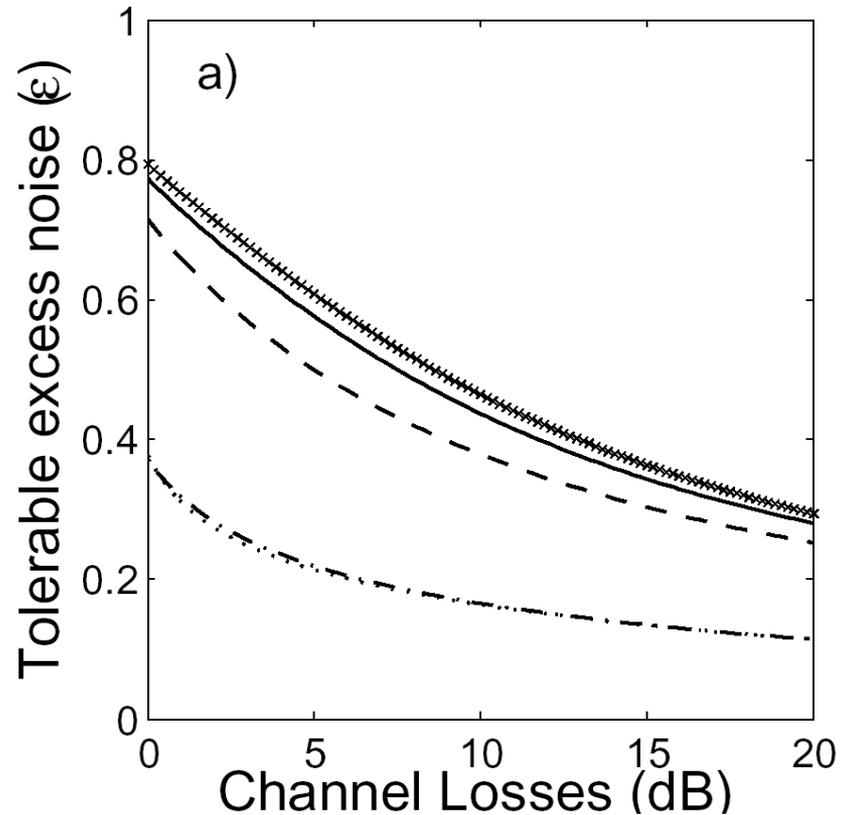
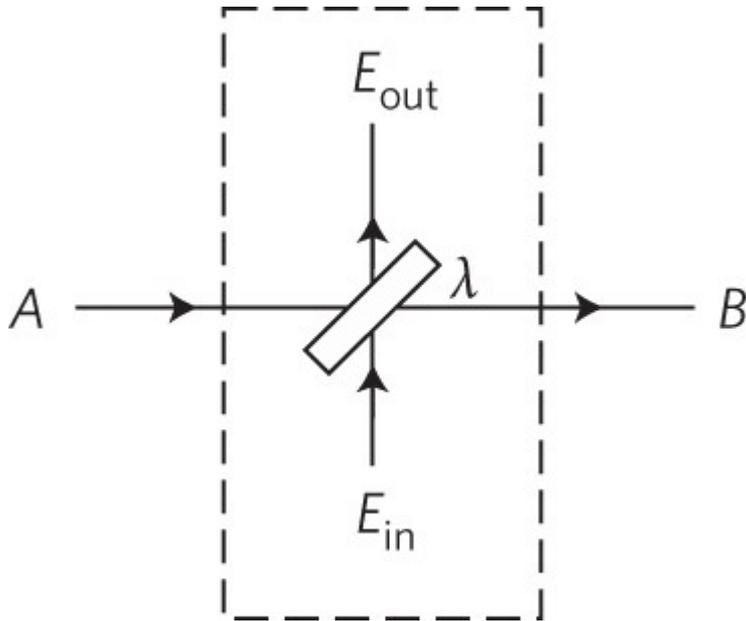
L.S. Madsen, V.C. Usenko, M. Lassen, R. Filip and U.L. Andersen, *Nature Communication* 3, 1083 (2012).

QKD with **squeezed** states is more robust!

Maximal distance of secure communication increases **linearly** with squeezing.

V.C. Usenko and R. Filip, *New J. Phys.* **13**, 113007 (2011).

CHANNEL NOISE IS LIMITING!



If we eliminate **noise** in transmission channel, secure key can be transmitted to **any distance**. **Losses** in channel are tolerable.



NO GO THEOREM FOR GAUSSIAN ERROR CORRECTION OF GAUSSIAN WHITE-NOISE MARKOVIAN CHANNELS

Julien Niset, Jaromir Fiurasek, Nicolas J. Cerf, Phys.Rev.Lett.102, 120501 (2009)



NO GO THEOREM FOR GAUSSIAN ERROR CORRECTION OF GAUSSIAN WHITE-NOISE MARKOVIAN CHANNELS

As before we did for

- squeezing and entanglement distillation [R. Dong et al., Nat. Phys. 4, 919 (2008)]
- noiseless amplification [M.A. Usuga et al., Nat. Phys. 6, 767 (2010)]

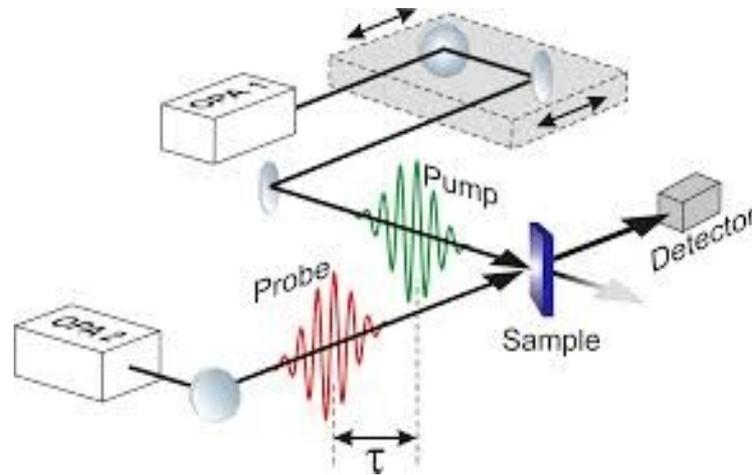


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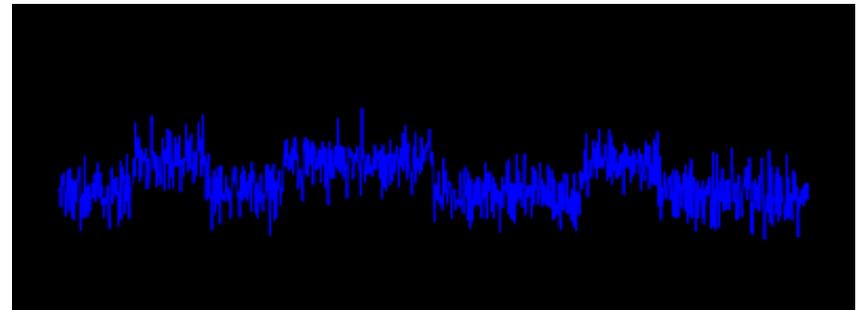
- squeezing and entanglement distillation [R. Dong et al., Nat. Phys. 4, 919 (2008)]
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IDEA: PUMP-PROBE METHOD

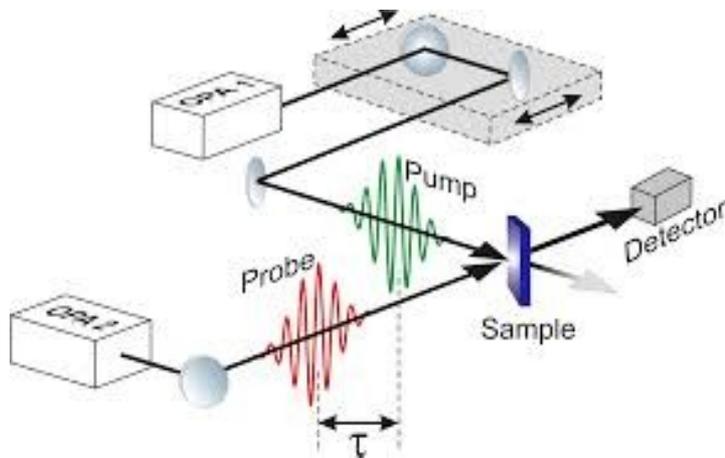


If time delay τ is small, probe pulse can measure changes of sample caused by pumping pulse. Method exploits high correlation between consecutive pulses caused by slow response of sample (correlation spectroscopy).

If two pulses feel, at least partially, a correlated noise in a channel, we might be able to eliminate it.

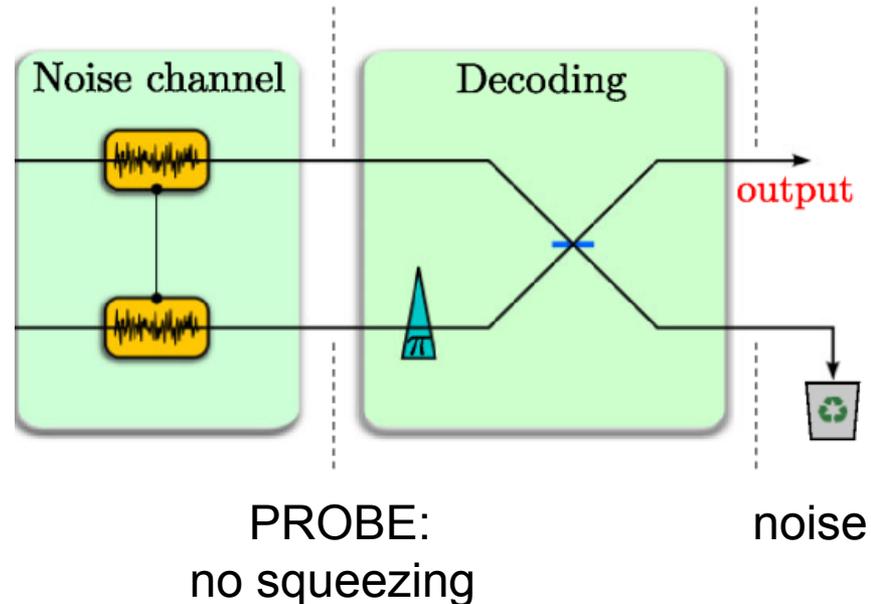


SQUEEZING EXTRACTION



SIGNAL:
no squeezing

Squeezing!!

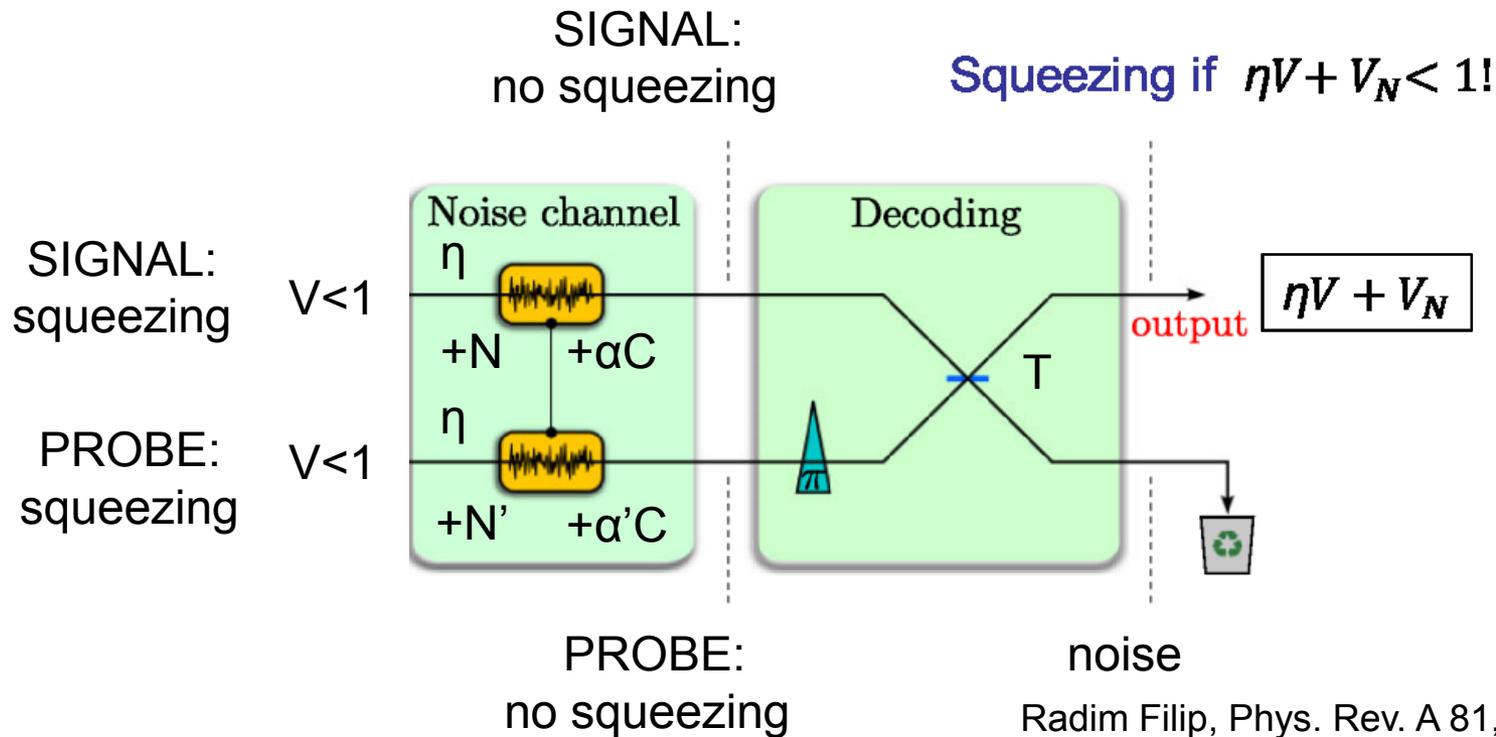


Radim Filip, Phys. Rev. A 81, 032330 (2010).

Interference of signal and probe gives better results than homodyne measurement of probe and electro-optical modulation of signal.

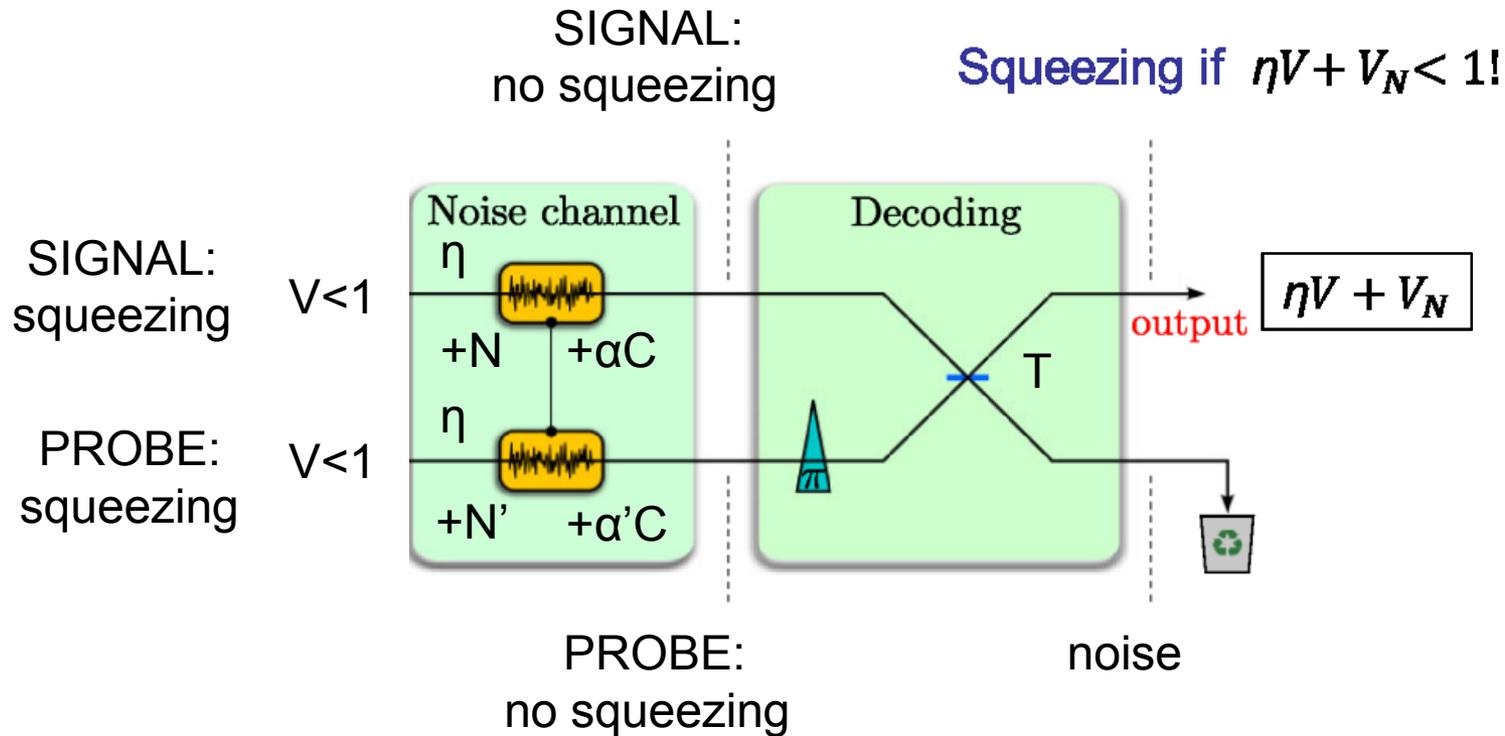
Perfectly correlated classical noise (also asymmetrical) can be always eliminated by interference of signal and probe.

ASYMMETRICAL NOISE



For two Gaussian channels with the same transitivity η and variance V_N of uncorrelated noise, **asymmetrical correlated** noise can be **fully** compensated by adjusting T and both transitivity η and variance V_N do not change!
IMPOSSIBLE BY MEASUREMENT AND FEEDFORWARD

TWO VIEWS ON CORRELATIONS



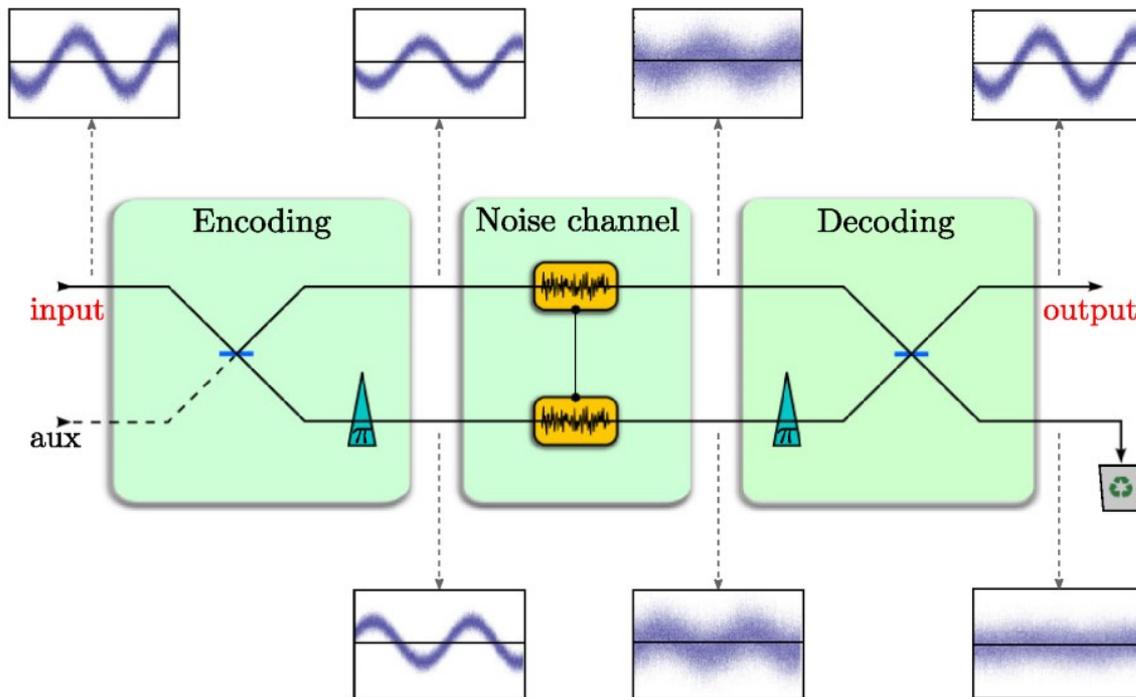
Radim Filip, Phys. Rev. A 81, 032330 (2010).

$$\min_{a,b} \langle (aX_S - bX_P)^2 \rangle, \text{ where } a, b \text{ (} a^2 + b^2 = 1 \text{)}$$

For measurement of probe of feed-forward correction:

$$V_{S|P} = \min_g \langle (X_S - gX_P)^2 \rangle$$

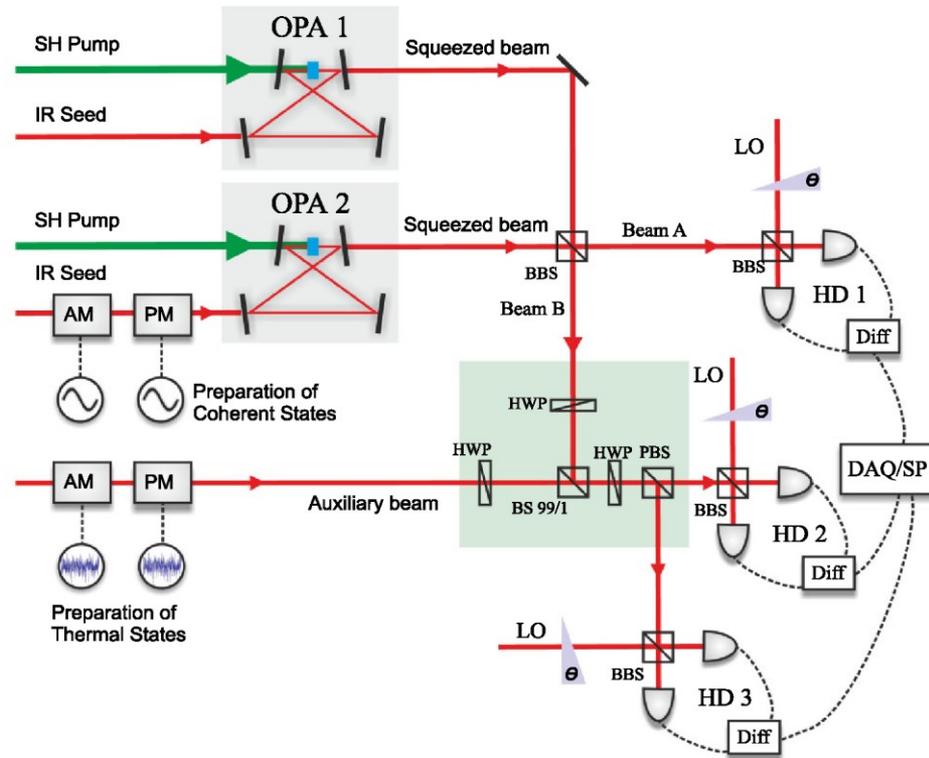
CHANNEL NOISE IS NOT PRINCIPALLY LIMITING



Asymmetrical correlated noise in channel is completely eliminated for any quantum state transmitted in channel.

M. Lassen, A. Berni, L.S. Madsen, R. Filip, U.L. Andersen, Phys. Rev. Lett 111, 180502, (2013).

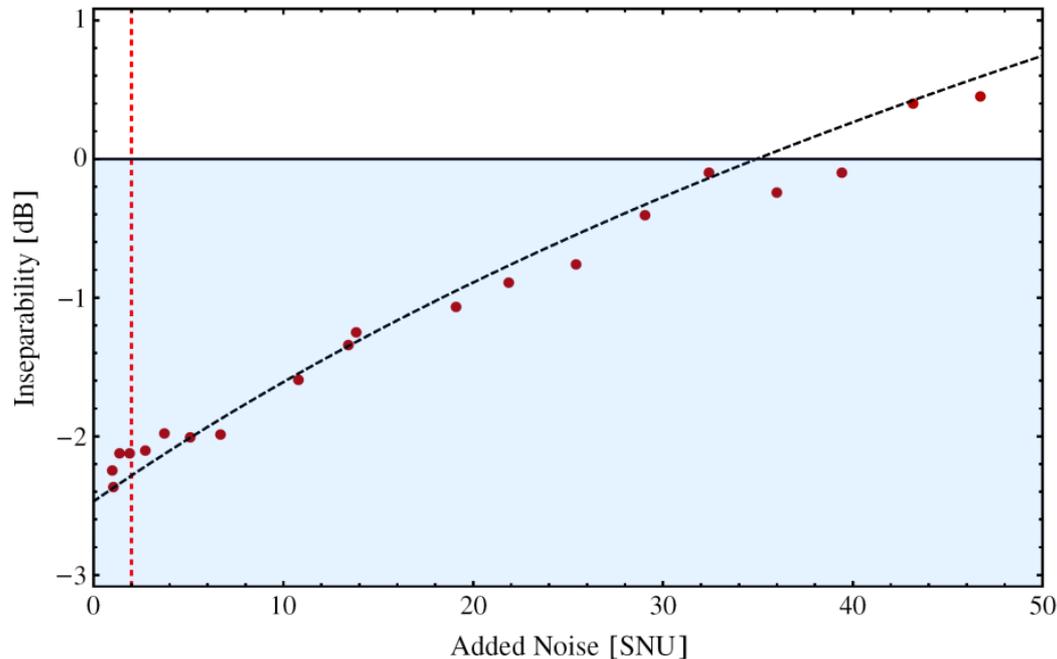
CHANNEL NOISE IS NOT PRINCIPALLY LIMITING



Experimental test for entangled states used before for quantum key distribution.

M. Lassen, A. Berni, L.S. Madsen, R. Filip, U.L. Andersen, Phys. Rev. Lett 111, 180502, (2013).

EXPERIMENTAL RESULT AS CONCLUSION



Reduction of channel noise depends on correlation and visibility of classical interference of transmitted quantum states.

M. Lassen, A. Berni, L.S. Madsen, R. Filip, U.L. Andersen, Phys. Rev. Lett 111, 180502, (2013).