Coherent Communication with Linear Optics

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What is Coherent Communication?

Discrete-variable coherent communication[1]

$$|x\rangle^A \rightarrow |x\rangle^A |x\rangle^B : x \in \{0,1\}$$

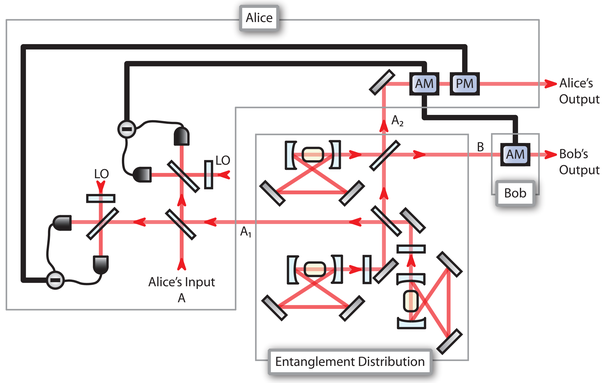
Continuous-variable coherent communication[2]

$$\begin{bmatrix} \hat{x}_A & \hat{p}_A \end{bmatrix} \rightarrow \begin{bmatrix} \hat{x}_{A'} & \hat{p}_{A'} & \hat{x}_{B'} & \hat{p}_{B'} \end{bmatrix}$$

$$\begin{aligned} \hat{x}_{A'} &= \hat{x}_A \\ \hat{x}_{B'} &= \hat{x}_A + \hat{x}_{\Delta_X} \\ \hat{p}_{A'} &= \hat{p}_A + \hat{p}_{\Delta_X} \\ \langle \hat{x}_{\Delta_X} \rangle &= \langle \hat{p}_{\Delta_X} + \hat{p}_{B'} \rangle = 0 \\ \langle \hat{x}^2_{\Delta_X} \rangle &, \langle (\hat{p}_{\Delta_X} + \hat{p}_{B'})^2 \rangle \leq \epsilon \end{aligned}$$

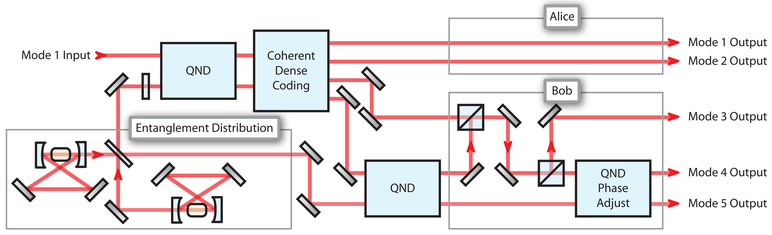
Similar to a nonlocal quantum nondemolition interaction (QND)

Coherent Communication Assisted by Entanglement and Classical Communication



Implements a coherent channel or a nonlocal QND using entanglement and classical communication

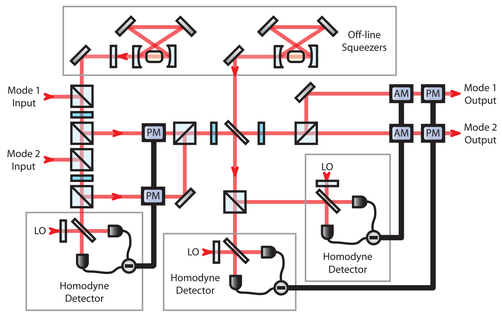
Coherent Teleportation



Implements a quantum channel using two coherent channels

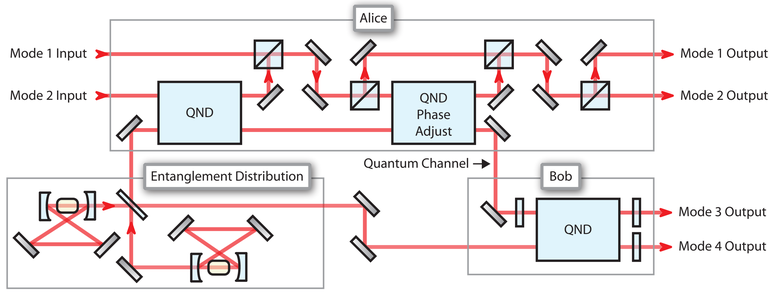
Alice and Bob also share entanglement at the end of the protocol

Linear-Optical QND Interaction



FMA's scheme[3] implements a QND with passive optical devices, off-line squeezers, homodyne detection, feedforward control, and conditional displacements

Coherent Superdense Coding



Implements two coherent channels or two nonlocal QNDs using entanglement and quantum communication

Noise Analysis

Each QND accumulates a noise of at most η_F where

$$\eta_F = \left(\frac{1-T}{1+T}\right)\left((1-\eta)/\eta T + \mathrm{e}^{-2r}\right)$$

and where T is transmittivity, η is detector efficiency, and r is squeezing strength

Noise affects performance of the coherent channels and the fidelity of coherent teleportation

References

[1] Aram Harrow. Phys. Rev. Lett. **92**, 097902 (2004).
[2] Mark M. Wilde, Hari Krovi, and Todd A. Brun. Phys. Rev. A **75**, 060303(R) (2007).
[3] Radim Filip et al., Phys. Rev. A **71**, 042308 (2005).