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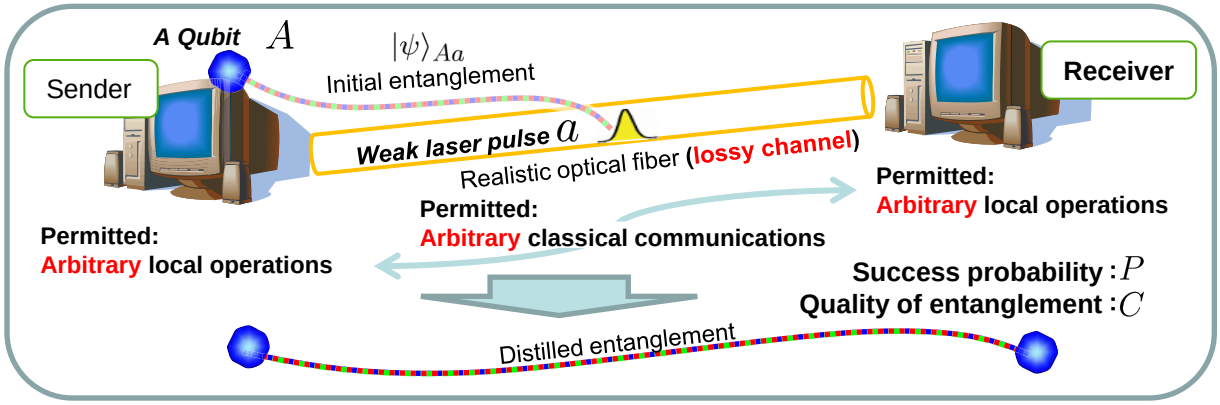
Quantum information exchange employing optics

Optimal entanglement generation protocol with laser light

***Abstract*— Quantum communication is a future technology that can provide fabulous functions. The most promising medium for realizing quantum communication is thought to be a combination of a weak laser pulse and an optical fiber. However, due to the actual loss in the optical fiber, there must be an upper limit to the quantum communication performance when we use this medium. The main contributions of all the existing theoretical researches with respect to the performance when we use this medium have been proposals of new quantum protocols with better performance than before. We give the theoretical limit of the performance by rigorously evaluating the trade-off between the quality of entanglement and the probability of success. This result reveals the capability of the existing scheme and will contribute to progress on quantum communication technology.**

Problem setting:

By using a realistic optical fiber and a weak laser pulse depending on a classical bit, a low quality entanglement is given. The purpose is to distill a high quality entanglement C with high probability P from the given initial entanglement.



Due to the optical loss, there must be a trade-off between the success probability and the quality of entanglement. This model generalizes all models previously used by studies about quantum communication efficiency. "Quality of the entanglement" indicates the distinguishability between quantum and classical information.

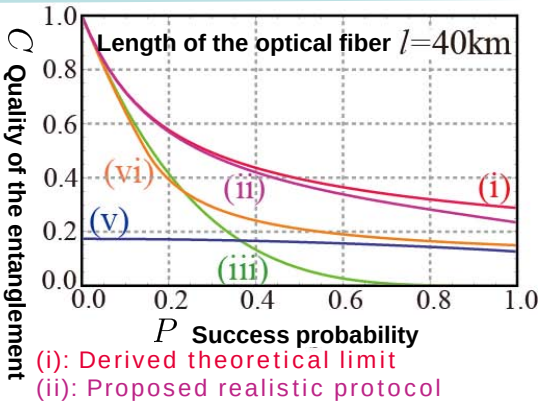
Result: Theoretical limit is derived

Upper limit of the quality of the entanglement with probability P

$$C^{\mathrm{upp}}(P) = \frac{u^{\frac{1-T}{T}}\sqrt{(1-u)(2P+u-1)}}{P} \quad \text{with}$$

$$u := \frac{1}{2}\left[(1-P)(2-T) + \sqrt{4P^2(1-T)+(1-P)^2T^2}\right]$$

T : **Transmittance of the optical fiber**



(i): Derived theoretical limit
(ii): Proposed realistic protocol
(iii),(vi),(v): Existing protocols

Related works

[1] K. Azuma, G. Kato, "Optimal entanglement manipulation via coherent-state transmission," *Physical Review A (PRA)* 85, 060303(R), 2012.

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