New Methods for Noiseless Linear Amplification and Quantum Teleportation of Multiphoton Quantum States

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We recently discovered a practical method of perfectly amplify multiphoton light [1]. This type of amplifier is useful for a huge variety of quantum technologies, such as quantum-secured communication, quantum-improved sensing, and quantum error correction. Our method uses common optical components, and is resistant to experimental imperfections. Before this research, practical perfect amplifiers were restricted to light containing up to a single-photon. Previous amplifier proposals attempted to circumvent this single-photon limit, however they produce distorted amplified light [2].

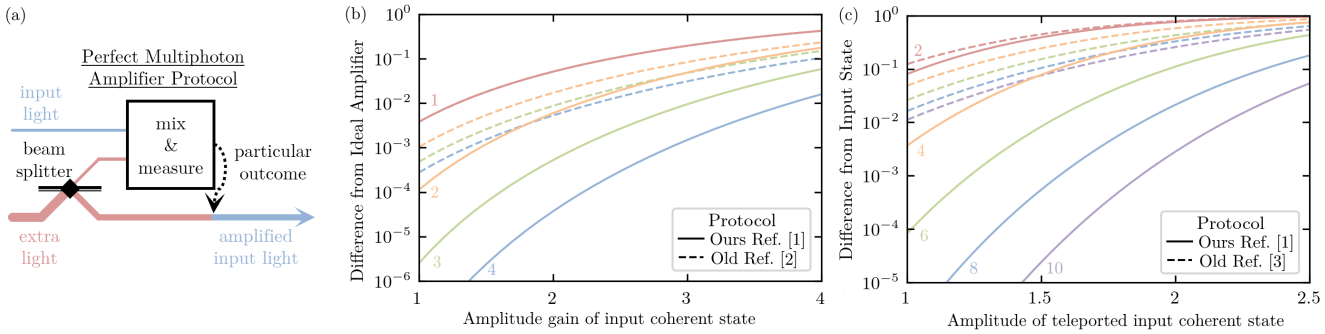

Figure 1: (a) Our protocol design [1], which is an excellent (b) amplifier (compared with Ref. [2]), and (c) teleporter (compared with Ref. [3]). The colour line numbers refer to the extra light photon numbers.

As shown in Fig. 1(a), our protocol works by introducing extra light, containing a chosen number of photons. Some of this extra light is mixed with the input light, and then measured. Given that a particular measurement outcome occurs, the remaining extra light inherits all properties of the input light (i.e. quantum teleportation). If the remaining extra light is brighter, the result is an amplified version of the input light. Our method is better than established alternative amplifiers [2] and continuous-variable teleporters [3], as shown in Fig 1(b) and (c). We will also mention some new unpublished related results.

[1] J. J. Guanzon, M. S. Winnel, A. P. Lund, and T. C. Ralph, Ideal quantum teleamplification up to a selected energy cutoff using linear optics, *Physical Review Letters*, **128**, 160501 (2022).

[2] G. Y. Xiang, T. C. Ralph, A. P. Lund, N. Walk, and G. J. Pryde, Heralded noiseless linear amplification and distillation of entanglement, *Nature Photonics*, **4**, 316 (2010).

[3] U. L. Andersen, and T. C. Ralph, High-fidelity teleportation of continuous-variable quantum states using delocalized single photons, *Physical Review Letters*, **111**, 050504 (2013).