Optimal quantum machines by linear and non-linear optics

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Since manipulations of qubits are constrained by the quantum mechanical rules, several classical information tasks can not be perfectly extended to the quantum world. The more relevant limitations in quantum information processing are the impossibility to perfectly clone any unknown qubit $|\phi>$ and to map it in its orthogonal state $|\phi^{\perp}>$. Even if these two processes are unrealizable in their exact forms, they can be optimally approximated by the so-called *universal quantum machines*: the optimal quantum cloning machine (UOQCM) and the universal-NOT (U-NOT) gate, which exhibit the minimum possible noise. Investigation of these optimal transformations is important since it reveals bounds on optimal manipulations of information with quantum systems.

The U-NOT gate and the UOQCM, have been contextually realized by adopting the process of stimulated emission generated by a single photon into an optical parametric amplifier [1]. We shall present how it is possible to implement the $1 \rightarrow 2$ UOQCM and the $1 \rightarrow 1$ U-NOT gate by slightly modifying the quantum state teleportation protocol [2]. In this case the UNOT gate is transferred in a different location, we deal hence with the teleportation of a quantum operation: the Tele-UNOT gate. A complete experimental realization of the protocol by a fully *linear* method will be discussed.

[1] F. De Martini, V.Buzek, F. Sciarrino, and C. Sias, *Nature (London)* 419, 815 (2002); F. De Martini, D. Pelliccia, and F. Sciarrino, *Phys. Rev. Lett.* 92, 067901(2004).

[2] M. Ricci, F. Sciarrino, C. Sias, and F. De Martini, *Phys. Rev. Lett.* 92, 047901 (2004); F. Sciarrino, C. Sias, M. Ricci, and F. De Martini, *Phys. Lett. A* 323, 34 (2004).