

Teleportation of single-mode optical states by means of a single photon

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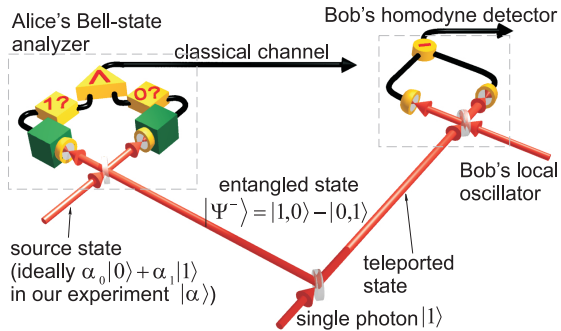
A single-photon Fock state $|1\rangle$ incident upon a symmetric beam splitter will generate an entangled Bell-type state $|\Psi^-\rangle = |1,0\rangle - |0,1\rangle$. This state can be used to perform quantum teleportation (QT) of superposition states $\alpha_0|0\rangle + \alpha_1|1\rangle$ by means of the standard Bennett protocol [1] (Fig). QT in the Fock basis is an important element of the recent linear optical quantum computation proposal [2].

Experimental implementation of this protocol appeared challenging because of (a) lack of robust pure-mode single-photon sources; (b) inability of commercial single-photon detectors (SPD) to

resolve the number of incident photons (as required by Alice's bell-state analyzer) and (c) lack of means of characterizing the pulsed teleported state. Recent experimental advances made by our group have addressed (a) and (c) above [3]; Pegg *et al.* have shown that even with commercial detectors the teleportation protocol would exhibit high fidelity for $\alpha_1 / \alpha_0 \lesssim 1$ [4]. If a weak coherent state $|\alpha\rangle$ is used instead of the superposition $\alpha_0|0\rangle + \alpha_1|1\rangle$, QT will cut off the multi-photon terms in the teleported output ("quantum scissors"). Here we present an experimental implementation of the Pegg *et al.* proposal. In contrast to a related experiment [5] we teleport a single-mode state rather than two-mode entanglement.

We have generated single photons by means of conditional measurements on a biphoton produced via parametric down-conversion and directed them into the setup shown above. A successful measurement by Alice's Bell-state analyzer triggered Bob's balanced homodyne detector. To demonstrate the nonclassical nature of teleportation we varied the optical phase of the source state and observed the phase of the teleported state to vary accordingly although nothing was done directly to Bob's share of the original entangled state $|\Psi^-\rangle$. We also characterized the teleported state by means of homodyne tomography for various α 's. As expected, the teleportation fidelity approached unity for low α but quickly fell off with this parameter increasing.

We note that our teleportation protocol is of *a priori* nature in the context of the discussion [6], i.e. successful teleportation events need not be postselected according to the result of Bob's measurements.



Scheme of the teleportation experiment. The teleportation event occurs when Alice's "left" SPD detects exactly one photon while the "right" one detects none. Bob's share of the original entangled state $|\Psi^-\rangle$ then becomes a copy of the source state.

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