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Experimental Quantum Encoder for Single-Photon Qubits

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Abstract: We describe an experiment in which linear optics, post-selection, and GHZ-like three-photon interference effects were used to probabilistically encode a single-photon qubit into the logical state of two photons.

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Encoding the value of a single physical qubit into the logical state of multiple qubits can be used to reduce the effects of noise and loss in quantum information processing devices [1]. One example of such a quantum encoding operation can be written as $a|0\rangle + b|1\rangle \rightarrow a|00...0\rangle + b|11...1\rangle$.

Here we describe a proof-of-principle experiment in which a physical qubit represented by the polarization state of a single photon was probabilistically encoded into a logical qubit represented by a two-photon quantum state. An overview of the quantum encoding device considered here is shown in Fig.1, and the theory of its operation is described in ref.[2].

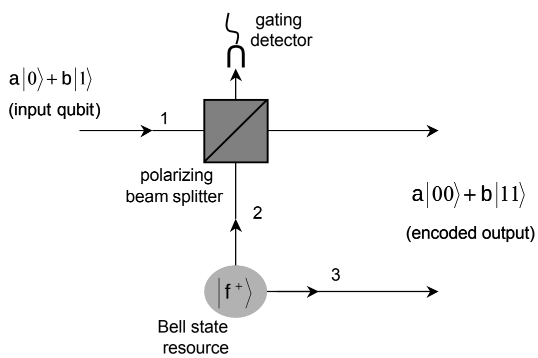

Fig. 1. Probabilistic quantum encoder comprised of a polarizing beam splitter and an entangled resource pair of photons [2].

The device is primarily comprised of a single input qubit photon, a polarizing beam splitter, and a resource pair of entangled photons [2]. Therefore, from an experimental point of view the quantum encoder can essentially be thought of as three-photon interferometer. In our experiment, the Bell-state resource pair was derived from a pulsed parametric down-conversion source, while the input qubit photon was obtained from a weak coherent state. To suppress the problems associated with the random nature of these sources, as well as photon loss and detector inefficiencies, events were only accepted in which one photon was registered in each of the three output ports (eg. the coincidence basis). This strategy was similar to that used in our recent demonstration of a probabilistic photonic controlled-NOT gate [3] for linear optics quantum computing [4].

Typical results of the quantum encoding operation are shown in Fig. 2. The data shows the number of three-photon events obtained for various input qubit values (polarizations), as a function of polarization analyzer settings in the two relevant output modes. Figs. 2(a) and (b) show the results of the basis state encodings: 0→00 and 1→11, while Fig. 2(c) shows results obtained when the input qubit was polarized at 45°. For the latter case the quantum encoder is expected to produce the Φ^+ Bell state in its outputs, and this data demonstrates the ability to maintain the coherence of superposition-state input qubits.

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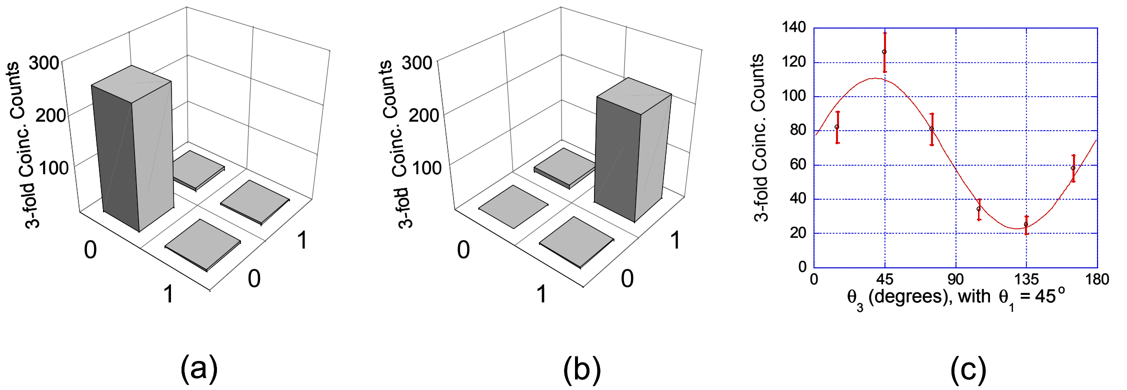

Fig. 2. Experimental results from the quantum encoder experiment.

Additional settings of the experimental apparatus also allowed the observation of three-photon GHZ states of the form $|\psi\rangle = 1/\sqrt{2}\left(|000\rangle + |111\rangle\right)$. In contrast to earlier work involving two down-conversion pairs [5], the basic idea here was to produce this three-photon entangled state using one down-converted photon pair and a third photon post-selected from a weak coherent state [6].

[1] *Quantum Computing and Quantum Information,* M.A. Neilsen and I.L. Chuang (2000).
[2] T.B. Pittman, B.C. Jacobs, and J.D. Franson, Phys. Rev. A **64** 062311 (2001).
[3] T.B. Pittman, M.J. Fitch, B.C. Jacobs, and J.D. Franson, Phys. Rev. A **68** 032316 (2003).
[4] E. Knill, R. LaFlamme, and G.J. Milburn, Nature **409**, 46 (2001).
[5] D. Bouwmeester et.al., Phys. Rev. Lett. **82**, 1345 (1999).
[6] J.G. Rarity and P.R. Tapster, Phys. Rev. A **59**, R35 (1999).