Optical Cluster State Generation without Number Resolving Photon Detectors

Mark Wilde[1], **Federico M. Spedalieri**[2], **Jonathan P. Dowling**[3,4], **Hwang Lee**[3]

[1]*Signal and Image Processing Institute, Department of Electrical Engineering, University of Southern California, Los Angeles, California 90007, USA*

[2]*Department of Electrical Engineering, University of California, Los Angeles, Los Angeles, California 90095*

[3]*Hearne Institute for Theoretical Physics, Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001, USA*

[4]*Institute for Quantum Studies, Department of Physics, Texas A&M University, College Station, Texas 77843-4242 USA*

Abstract: We propose a controlled phase gate [1] for linear optical quantum computing without using photon detectors that are photon number resolving. If the dark count probability is low, we can reliably generate optical cluster states.

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We propose a polarization encoding [2] scheme for reliable optical cluster state generation. We do not require photon detectors with photon number resolving capability. They only need to detect the presence or absence of photons.

The following diagram illustrates our proposed method for implementing this gate.

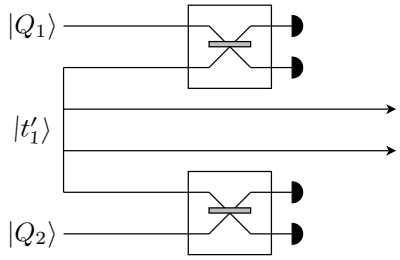

Fig. 1. Proposed scheme for a controlled phase gate.

The first and second qubits $|Q_1\rangle$ and $|Q_2\rangle$ are polarization encoded qubits.

$$|Q_i\rangle = \alpha_i|H\rangle + \beta_i|V\rangle \tag{1}$$

The four mode state $|t_1'\rangle$ is as follows.

$$|t_1'\rangle = \frac{1}{2}\left(|VHVH\rangle + |HVVH\rangle + |VHHV\rangle - |HVHV\rangle\right) \tag{2}$$

Using $|t_1'\rangle$, we perform a non-deterministic controlled-phase operation on $|Q_1\rangle|Q_2\rangle$ without number resolving detectors. Furthermore, we show how to generate the $|t_1'\rangle$ state without using number resolving detectors.

References

1. E. Knill, R. Laflamme, and G.J. Milburn, Nature **409**, 46 (2001).
2. F. M. Spedalieri, H. Lee, and J. P. Dowling, Phys. Rev. A **73**, 012334 (2006).