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Linear-optics implementations of nondestructive single-photon measurements and arbitrary quantum channels

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We consider implementations of quantum information processing with linear optics. The first result regards the realization of an arbitrary quantum channel on a single-photon multimode qudit. [1] We prove that any such channel can be realized perfectly albeit only stochastically under a set of assumptions that make our scheme amenable to experimental realization. We discuss in detail the optimal probability of success of the scheme, that turns out to be connected to the entanglement properties of the Choi- Jamiolkowski state isomorphic to the channel to be realized. The second result [2] is an improvement of a simple circuit proposed by Nicholas et al. [3] that heralds the presence of single photons without disturbing the information encoded in polarization. This scheme again only works stochastically but its success probability can be made arbitrarily high by increasing the complexity of the ancilla state used. We consider the application of this circuit to counteract transmission loss in device independent quantum key distribution.
For both cases we briefly discuss the possible challenges of an actual implementation.

[1] M. Piani, D. Pitkanen, R. Kaltenbaek, N. Lütkenhaus, arXiv:1012.3473.
[2] D. Pitkanen, X.F. Ma, R. Wickert, P. Van Loock, N. Lütkenhaus, in preparation.
[3] G. Nicholas, S. Pironio, N. Sangouard, Phys. Rev. Lett. **105**, 07051 (2010).