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Experimental quantum noisy channel detection

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We report on the experimental implementation of a quantum noisy channel detection method proposed recently [1], which requires fewer measurements than standard quantum process tomography. The method exploits the fact that a channel acting on a quantum system of dimension d can be described by a corresponding bipartite state of dimension d^2 known as the Choi state of the channel. Thus, by measuring entanglement properties of the Choi state, one can infer specific properties of the quantum channel. We experimentally applied this method to a single qubit depolarizing channel: we prepared a two photon polarization entangled state and sent one photon through a Pauli channel implemented with liquid crystal retarders [2]; by performing an entanglement witness measurement on the two photon state after the channel, we were able to detect whether or not the channel was entanglement breaking for different amounts of noise in the channel, in very good agreement with the theory. We report further results regarding the extension of this method to the detection of a CNOT gate operation (a two qubit channel) in presence of dephasing noise on both qubits. To this end, we used a path-polarization two photon hyperentangled state [3], one photon of which was sent through the CNOT gate and was submitted to noise both in path and polarization. Our witness measurement results show again an excellent agreement with the theoritically predicted behaviour.

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[3] M. Barbieri, C. Cinelli, P. Mataloni, and F. De Martini, Phys. Rev. A 72, 052110 (2005)