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Optical Hyperentangled Bell State Analysis[1] NICHOLAS LARACUENTE, PAUL KWIAT, University of Illinois Urbana-Champaign — The ability to measure Bell states is essential throughout theories and experiments that separate quantum information from classical, and in applications such as optical quantum computing and communication. The lack of efficient non-linear optics is a primary hindrance to Bell state analysis (BSA). While it is possible (using auxiliary photons) to perform qubit BSA with an arbitrary high probability of completely distinguishing the measured Bell state, this leaves an open question of whether auxiliary-enhanced BSA on hyperentangled or qudit-entangled photons is possible with sufficient accuracy and efficiency to be practical. We prove that in an ideal case, a single auxiliary pair can allow successful teleportation of a 2-qubit hyperentangled Bell state with 1/16 probability of success; we then analyze the effect of more realistic auxiliary and primary pair production on this scheme. We argue that auxiliary enhancement will generalize to higher dimensional hyperentanglement and that it is possible to further increase the success rate with additional auxiliaries. Finally, we compare this method with quantum non-demolition-based BSA and assess the practicality of packing more qubits into each photon for communication, computation and the study of quantum foundations.

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