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Transmission Phase Holography: Spatial-Mode Filter Design for Quantum Information Applications RACHEL HILLMER, JULIO BARREIRO, PAUL KWIAT, University of Illinois at Urbana-Champaign — Photon spatial modes offer access to promising new applications in quantum information because they provide a higher-dimensional basis set than the usual two-dimensional one associated with polarization. Downconversion experiments have demonstrated spatial-mode entanglement [1], and even hyperentanglement in polarization and spatial mode [2]. However optical elements currently lack the refinement necessary to perform efficient, high-fidelity operations using spatial modes. Holographic filters for Laguerre-Gaussian and Hermite-Gaussian laser modes can act as modes converters, and have long been studied (under the terms "modans" and "kinoforms") for use in electrical engineering applications [3,4]. Her we present analytical refinements and optimizations of these techniques, with predicted mode fidelities over 95% and diffraction efficiencies up to 98%. Results of our experimental implementions of these solutions are presented.
[1] Walborn, S.P, et al, "Entanglement and conservation of orbital angular momentum in spontaneous parametric down-conversion," Phys. Rev. A **69**, 023811 (2004); [2] Barreiro, J.T. et al, "Generation of Hyperentangled Photon Pairs," Phys. Rev. Lett. **95**, 260501 (2005); [3] Soifer, V.A., "Methods of Computer Design of Diffractive Optical Elements," John Wiley & Sons, Inc., 2002; [4] Golub, M. and Soifer, V., "Laser Beam Mode Selection by Computer Generated Holograms," CRC Press, Inc., 1994.

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