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Quantum process tomography of optical unitaries KEVIN VALSON JACOB, SUSHOVIT ADHIKARI, JONATHAN DOWLING, Louisiana State University — Characterizing quantum evolutions are of prime importance in quantum information. In the emerging area of photonic quantum technologies, this amounts to determining the unitary matrix which transforms the mode operators of a linear optical circuit. We propose a loss-tolerant method to fully characterize such unitaries by using only single photons. By inputting a single photon in a given input mode and finding the probability for it to be detected in all output modes, we find the moduli of all the matrix elements of the unitary. To find the phases of the matrix elements, we need the matrix elements to 'interfere' with each other. This is found by measuring the phase difference between two different paths taken by a photon. To implement this, we can either send in a photon superposed between any two input modes, or measure the output photon in a different mode basis. The former can be implemented by placing a 50:50 beamsplitter before the unknown unitary while the latter can be implemented by placing a beamsplitter after the unitary. We develop a scheme which optimizes the number of experimental configurations necessary for the full tomography of a 'd' dimensional unitary. Although the Hilbert space is exponentially large in the dimension, only $O(d^2)$ measurements suffice.

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