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Ultrafast Quantum Process Tomography via Continuous Measurement and Convex Optimization[1] CHARLES BALDWIN, CQuIC University of New Mexico, CARLOS RIOFRIO, Free University of Berlin, IVAN DEUTSCH, CQuIC University of New Mexico — Quantum process tomography (QPT) is an essential tool to diagnose the implementation of a dynamical map. However, the standard protocol is extremely resource intensive. For a Hilbert space of dimension d, it requires d^2 different input preparations followed by state tomography via the estimation of the expectation values of d^2-1 orthogonal observables. We show that when the process is nearly unitary, we can dramatically improve the efficiency and robustness of QPT through a collective continuous measurement protocol on an ensemble of identically prepared systems. Given the measurement history we obtain the process matrix via a convex program that optimizes a desired cost function. We study two estimators: least-squares and compressive sensing. Both allow rapid QPT due to the condition of complete positivity of the map; this is a powerful constraint to force the process to be physical and consistent with the data. We apply the method to a real experimental implementation, where optimal control is used to perform a unitary map on a $d = 8$ dimensional system of hyperfine levels in cesium atoms, and obtain the measurement record via Faraday spectroscopy of a laser probe.

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