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Quantum gate-set tomography[1]

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Quantum information technology is built on (1) physical qubits and (2) precise, accurate quantum logic gates that transform their states. Developing quantum logic gates requires good characterization – both in the development phase, where we need to identify a device's flaws so as to fix them, and in the production phase, where we need to make sure that the device works within specs and predict residual error rates and types. This task falls to quantum state and process tomography. But until recently, protocols for tomography relied on a pre-existing and perfectly calibrated reference frame comprising the measurements (and, for process tomography, input states) used to characterize the device. In practice, these measurements are neither independent nor perfectly known – they are usually implemented via exactly the same gates that we are trying to characterize! In the past year, several partial solutions to this self-consistency problem have been proposed. I will present a framework (gate set tomography, or GST) that addresses and resolves this problem, by self-consistently characterizing an entire set of quantum logic gates on a black-box quantum device. In particular, it contains an explicit closed-form protocol for linear-inversion gate set tomography (LGST), which is immune to both calibration error and technical pathologies like local maxima of the likelihood (which plagued earlier methods). GST also demonstrates significant (multiple orders of magnitude) improvements in efficiency over standard tomography by using data derived from long sequences of gates (much like randomized benchmarking). GST has now been applied to qubit devices in multiple technologies. I will present and discuss results of GST experiments in technologies including a single trapped-ion qubit and a silicon quantum dot qubit.

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