Implementation of a Toffoli Gate with Superconducting Circuits

ARKADY FEDOROV, LARS STEFFEN, MATTHIAS BAUR, ETH Zurich, MARCUS DA SILVA, Raytheon BBN Technologies, ANDREAS WALLRAFF, ETH Zurich — The Toffoli gate is an important primitive in many quantum circuits and quantum error correction schemes. Here we demonstrate the implementation of a Toffoli gate with three superconducting transmon qubits coupled to a microwave resonator [1]. Following Ralph et al. [2] we used the third energy level of the transmon qubit to significantly reduce the number of elementary gates needed to implement the Toffoli gate in comparison to approaches using two-level systems only. A similar scheme to realize a Toffoli-class gate has independently been devised on a system of three logical qubits encoded in the states of two qubits and a resonator [3]. Our gate fidelity evaluated by both full process tomography and Monte Carlo process certification is $68.5 \pm 0.5\%$. The results reinforce the potential of macroscopic superconducting qubits for implementation of complex quantum operations and point at the possibility to implement quantum error correction schemes [4].


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