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Experimental realization of non-abelian geometric gates with a superconducting three-level system ABDUFARRUKH ABDUMALIKOV, J. M. FINK, K. JULIUSSON, M. PECHAL, S. BERGER, A. WALLRAFF, S. FILIPP, Department of Physics, ETH Zurich — Geometric gates hold promise to provide the building blocks for robust quantum computation. In our experiments, we use a superconducting three-level system (transmon) to realize non-adiabatic non-abelian geometric gates. As computational basis we choose the ground and second excited states, while the first excited state acts as an ancilla state. The gates are realized by applying two resonant drives between the transmon levels. During the geometric gate ration of the amplitudes of the two drive tone is kept constant. Different gates are obtained for different ratio of the drive tones. We implement a Hadamard, a *NOT* and a phase gates with the fidelities of 95%, 98%, and 97% as determined by full process tomography and maximum likelihood methods. We explicitly show the non-abelian nature of gates by applying two non-commuting gates in alternating order. The demonstrated holonomic gates are not exclusive to superconducting quantum devices, but can also be applied to other three level systems with similar energy level structure.

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