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Contributions to the theory of Clifford-cyclotomic circuits

Circuit design is an important aspect of quantum computation theory, and the question of constructing a circuit that exactly represents a given arbitrary operator is prominent in the research area. The universal Clifford-cyclotomic gate sets are commonly used as the building blocks for circuit synthesis, consisting of the well-known Clifford gates and a rotation around the z-axis, where the angle is a rational multiple of π. This rotation, along with the Clifford gates, corresponds to certain subrings of the cyclotomic number fields generated by n-th roots of unity; and hence properties of algebra and number theory can be leveraged to solve this problem. In this talk, we will study the specific case of the 16th root of unity, also known as the Clifford+$\sqrt{T}$ gate set. Previous results on the Clifford+T gate set are well-understood within the field, and we have a concrete idea of the unitary group generated by Clifford+T, with and without ancillas. From here, we apply properties of determinants in block matrices to construct an embedding from the unitary group of Clifford+$\sqrt{T}$ into a specific subgroup of Clifford+T, where the exact synthesis algorithm can be performed without ancillas. This gives an improvement on the minimum number of ancillas required for Clifford-cyclotomic synthesis, which cuts down on the cost of circuit construction.