Qutrit Entanglement via the Differential AC Stark Shift

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Ternary quantum information processing in circuit quantum electrodynamics devices poses a promising alternative to its more popular binary counterpart through larger computational spaces and proposed advantages in quantum simulation.[1] The weakly anharmonic nature of transmons[2] makes them ideal candidates for operation as qutrits. Recent advancements in ternary quantum computing, such as qutrit randomized benchmarking[3] and quantum information scrambling on a qutrit device[4], have been key in enabling qutrit development and in demonstrating its value in quantum simulation. However, effectively engineering a flexible two qutrit entangling interaction remains a central challenge towards realizing the inherent scaling advantages of qutrits. In this work, we apply the differential AC Stark shift to implement a flexible, microwave activated, and tunable cross Kerr coupling between two fixed frequency transmon qutrits, expanding on similar work performed for a tunable ZZ interaction with transmon qubits[5]. We then leverage this tunable coupling to implement a scheme for an efficient and flexible high fidelity two qutrit C-Phase gate.

References

[1] Wang *et. al.* Frontiers in Physics **8**, 589504 (2020)
[2] J. Koch *et al.* Phys. Rev. A **76**, 042319 (2007)
[3] Morvan *et al.* Phys. Rev. Lett. **126**, 210504, (2021)
[4] M. S. Blok *et al.* Phys. Rev. X **11**, 021010 (2021)
[5] Mitchell *et al.* Phys. Rev. Lett. **127**, 200502, (2021)

Figures

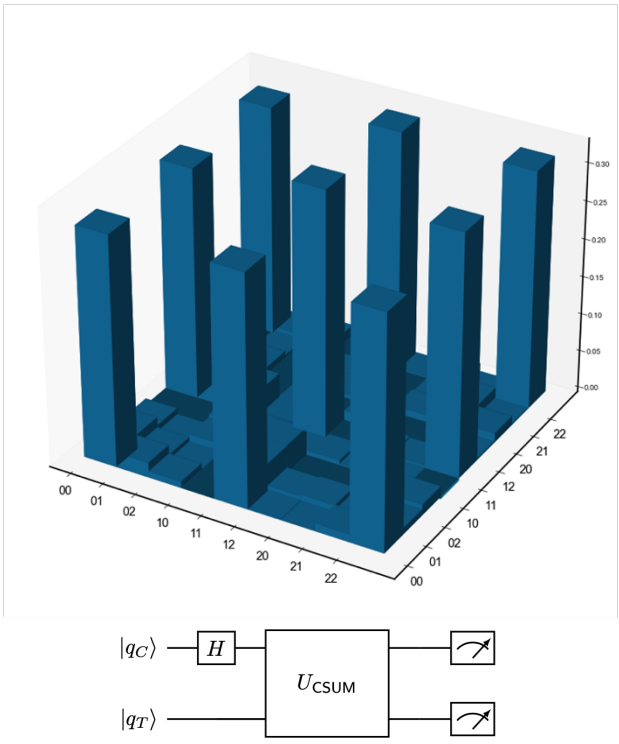

Figure 1: Experimentally reconstructed density matrix of 2 qutrit Bell State formed via our qutrit CZ gate. Our CSUM gate is performed via conjugating our qutrit CZ gate with single qutrit Hadamard gates.

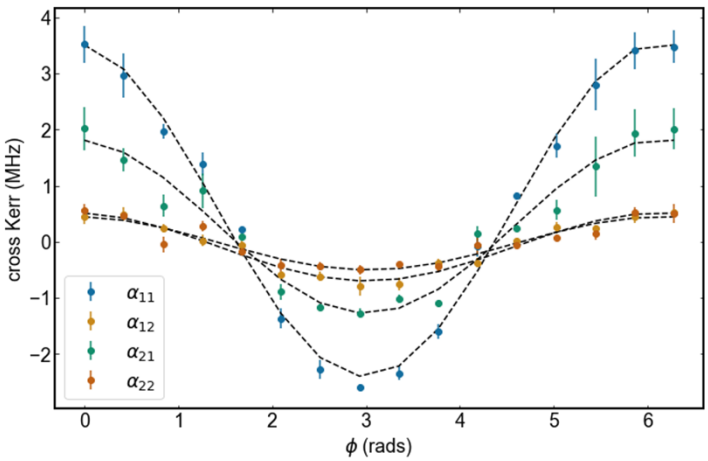

Figure 2: We demonstrate the tunable nature of our microwave activated coupling by sweeping the relative phase of our differential AC Stark drive and fitting the cross Kerr parameters to our Hamiltonian model.