Microwave-activated gates between transmon and fluxonium qubits

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Abstract

We propose and analyze two types of microwave-activated gates between a fluxonium and a transmon qubit, namely a cross-resonance and a CPHASE gate. The large frequency difference between a transmon and a fluxonium makes the realization of a two-qubit gate highly nontrivial. When the inductive energy of the fluxonium is of order comparable to its Josephson energy, the fluxonium-transmon system allows for a strong cross-resonance effect mediated by the higher levels of the fluxonium over a wide range of transmon frequencies. This allows us to realize the cross-resonance gate by driving the fluxonium at the transmon frequency mitigating typical problems of the cross-resonance gate in transmon-transmon chips [1]. However, when the inductive energy of the fluxonium decreases and its fundamental frequency becomes O(10) MHz the cross-resonance effect tends to vanish. For this range of parameters, a fast microwave CPHASE gate can be implemented using the higher levels of the fluxonium [2]. In both cases, we perform numerical simulations of the gate showing that high fidelity can be obtained with gate times O(100) ns. Next to a detailed gate analysis, we consider the pros and cons of these gates in a multi-qubit surface code architecture. We provide a comparison of our architecture with the only transmon case and the recently proposed only fluxonium architecture [3].

References

[1] J. Hertzberg et al., npj Quantum Information 7: 129(2021)
[2] Q. Ficheux et al, Phys. Rev. X 11, 021026 (2021)
[3] L. Nguyen et al, arXiv:2201.09374 (2022)

Figures

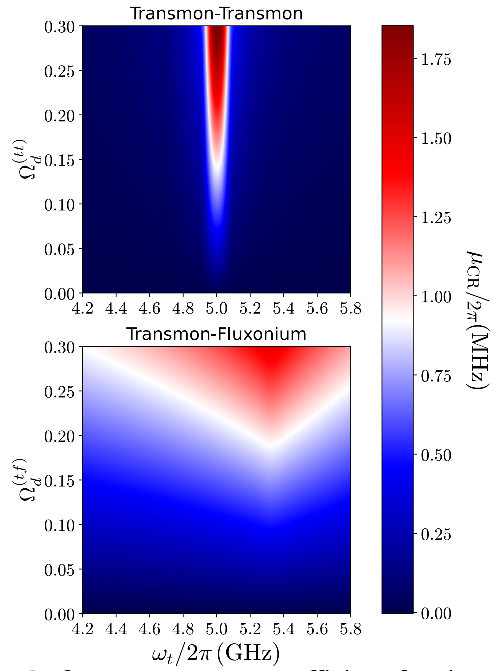

Figure 1: Cross-resonance coefficient for the transmon-transmon case (top) and transmon-fluxonium case (bottom) as a function of the frequency of the target transmon and dimensionless drive strenghts. In the fluxonium-transmon case the cross-resonance coefficient is larger for a wide range of target transmon frequency compared to the transmon-transmon case. This mitigates the problem of frequency collisions, which limits the fabrication yield in fixed-frequency transmon-transmon chips.