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Time-domain measurements with superconducting flux qubits for diabatic quantum annealing experiments

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Quantum annealing is an optimization method conventionally performed in an adiabatic fashion. Adiabatic quantum annealing (AQA) gradually changes the Hamiltonian so that the system stays in an instantaneous ground state of the Hamiltonian at all times. However, this slow process could hamper computational speedup. In contrast, diabatic quantum annealing (DQA) allows transitions between the ground state and excited states during the anneal. Hence the annealing process can take less time, enabling quantum speedup. In theory, DQA could be achieved by exploiting the interference effect from the Landau-Zener-Stückelberg (LZS) transition as a shortcut to adiabaticity. Our goal is to execute the LZS experiment on high-Q superconducting flux qubits. Typically, the LZS experiment is performed in the steady state, using a continuous-wave drive. The result of averaging many drive cycles makes the definition of the environmental effect challenging. Instead of using a continuous-wave drive, we aim to use a single pulse sequence to drive the system through the avoided crossing just one time. This technique creates a sensitive probe for decoherence and gives better visibility of the environmental impact on the qubit. Here, we characterize and calibrate a superconducting device consisting of a flux qubit, a quantum flux parametron, and a tuneable resonator in a dilution refrigerator, which cools the device down to 10 mK. Device calibration is performed to account for the crosstalk among the qubit, the quantum flux parametron, and the tuneable resonator. Qubit two-tone energy spectroscopy is subsequently derived using continuous- wave measurements. Then, we establish a pulse readout measurement configuration for the LZS experiment towards DQA. Moreover, we investigate the impact of the readout pulse length when measuring a dispersive readout resonator. The results could suggest a suitable pulse length for the subsequent Rabi oscillation experiment.

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