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Optimization of quantum logic gates based on nonadiabatic Landau-Zener-Stückelberg-Majorana transitions

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Quantum logic gates applied to qubits are basic elements of the circuit model used for quantum computations. Usually, quantum gates are realized by a resonant excitation, resulting in Rabi oscillations, which lead to a periodic excitation of the qubit. It has certain limitations and complications, like neglecting counter-rotating terms. We investigate an alternative way for quantum control and performing of quantum logic gates with Landau-Zener-Stückelberg-Majorana (LZSM) transitions [1,2,3] using nonadiabatic driving and alternation of the two stages of evolution: adiabatic evolution and non-adiabatic transitions. We investigate mechanisms, dynamics, and ways to optimize single-qubit LZSM gates [1,3]. We apply the adiabatic-impulse model to describe multiple LZSM transitions [1,3], which we use to create LZSM-based quantum logic gates. Any single-qubit operation can be realized with only two LZSM transitions with an adjustable time of free evolution time before and after those transitions. To gain better fidelity and reduce quantum gates performing time, we can use multiple LZSM transitions. LZSM-based quantum logic gates in comparison with Rabi oscillations based gates allow us to reduce gate time with keeping fidelity high, enabling us to perform more gates before the impact from decoherence and relaxation becomes significant. Fig.1 shows the dynamics for the NOT (X) gate realized by double LZSM transitions.
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<img src="https://indico.bitp.kiev.ua/event/11/contributions/278/attachments/116/198/LZSMFig. 1. Dynamics for the NOT (X) gate with ground initial state with double LZSM transitions: (a) dynamics on the Bloch sphere, (b) dynamics of Bloch coordinates.

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