Dynamics and logic operations in two coupled triple quantum dot charge qubits

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We present theoretical investigations of a system of two charge qubits, each built of three coherently coupled quantum dots (TQD) in a triangular geometry. This is a modification of charge qubits built in double-dot systems, widely studied both theoretically [1] and experimentally [2]. Double-dot charge qubits enable a fast coherent manipulation of quantum states using only gate voltages, however, they are vulnerable to decoherence caused by interaction with phonons and charge noise. Hentschel *et. al.* [3] showed that the qubit built in the triple-dot system in the triangular geometry may be more robust to phonon-induced decoherence. They proposed also a way to perform two-qubit operations by switching on a tunneling coupling between qubits. However in their approach multiple qubit operations were needed to obtain a CNOT gate, which is a standard two qubit entangling gate.

Our approach is different. We show that the Ising type effective interaction between qubits can be generated by Coulombic (capacitative) couplings between dots of the neighboring qubits. This enables realization of different standard qubit gates, like CPHASE, CNOT or SWAP, using a single pulse only [1, 4]. Moreover we show, that also other types of interactions, like the Heisenberg type, are possible to obtain by changing a geometry of the interdot capacitative couplings. This result is different from that one obtained for two double-dot qubits, where an effective interqubit interaction is always of the Ising type [1]. The indicated flexibility opens a way for designing a coupling scheme most suitable for a specific two-qubit operation. To make this evident, we show that for the Heisenberg type interaction in TQD one can perform the Bogoliubov gate with an optimized operation time. The gate may be useful in simulations of a one-dimensional quantum Ising model in a transverse magnetic field [5]. Our results may motivate further studies on a triple quantum dot system in a triangular geometry, recently realized experimentally [6].

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