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Quantum computer with atomic logical qubits encoded on macroscopic three-level systems in common quantum electrodynamic cavity

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Abstract

We propose an effective realization of the universal set of elementary quantum gates in solid state quantum computer based on macroscopic (or mesoscopic) resonance systems - multiatomic coherent ensembles, squids or quantum dots in quantum electrodynamic cavity. We exploit an encoding of logical qubits by the pairs of the macroscopic two- or three-level atoms that is working in a Hilbert subspace of all states inherent to these atomic systems. In this subspace, logical single qubit gates are realized by the controlled reversible transfer of single atomic excitation in the pair via the exchange of virtual photons and by the frequency shift of one of the atomic ensembles in a pair. In the case of two-level systems, the logical two-qubit gates are performed by the controlling of Lamb shift magnitude in one atomic ensemble, allowing/blocking the excitation transfer in a pair, respectively, that is controlled by the third atomic system of another pair. When using three-level systems, we describe the NOT-gate in the atomic pair controlled by the transfer of working atomic excitation to the additional third level caused by direct impact of the control pair excitation. Finally, we discuss advantages of the proposed physical system for accelerated computation of some useful quantum gates.

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Keywords

encoded universality, excitation swapping gates, multi-atomic coherent ensembles, Quantum computer