Coupled Dynamics of a Spin Qubits in an Optical Dipole Microtraps

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Laser-cooled atoms, confined in dipole microtraps or optical tweezers, offer an original experimental platform for quantum computing and quantum simulation. Here we present a detailed theoretical investigation of the physics underlying implementation of a Rydberg two-qubit gate in such a system — a cornerstone protocol in quantum computing with single atoms. We focus on a blockade-type entangling gate and consider various decoherence processes limiting its performance in a real system. We present the results of our numerical simulations for the basic benchmarks of the entanglement protocol, namely, for purity and fidelity of the prepared entangled state of two qubits (see Fig. 1) and for the truth, table corresponding to the noisy two-qubit CNOT gate implemented with the protocol. We analyze and compare the cases of different experimentally accessible excitation geometries searching for an experimental configuration optimizing the entanglement preparation. Our methods and results may find implementation in numerical models for simulation and optimization of neutral atom-based quantum processors [1].

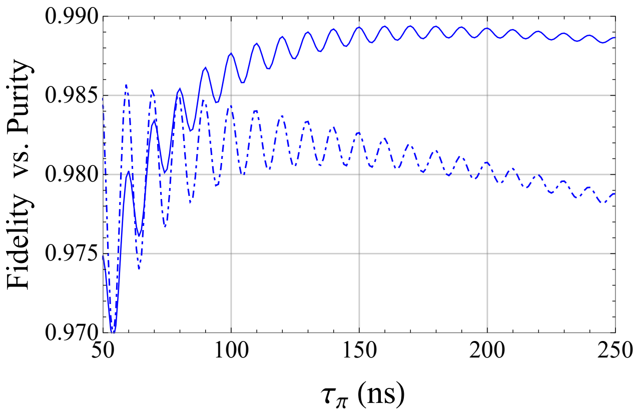

Figure 1: Fidelity (solid curves) and purity (dashed curves) of the entangled state, prepared by the protocol of Rydberg blockade with excitation by linearly polarized light beams and considered as a function of the π-pulse duration $\tau_\pi = \pi/|\Omega|$

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References

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