Trapping - Cooling - Quantum Control

Summer term 2019 - Lecturer: Tobias Schätz, Leon Karpa

Assignment sheet 11

please hand in your solutions by July 10th, 18:00.

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1) Quantum Gatekeeping

Please read the paper *Demonstration of a Fundamental Quantum Logic Gate* Phys. Rev. Lett. **75**(25) (1995) by C. Monroe et al. and answer the following questions.

a) A controlled-NOT (CNOT) quantum logic gate processes two qubits. How does a general CNOT gate transform the two input qubits? How are the two qubits implemented experimentally here? Sketch a simplified level scheme and mark the carrier- as well as the red- and blue-sideband transitions.

(3 Points)

b) How are the four initial states $|0\rangle|\downarrow\rangle$, $|1\rangle|\downarrow\rangle$, $|0\rangle|\uparrow\rangle$ and $|1\rangle|\uparrow\rangle$ prepared?

(2 Points)

c) Describe step by step how the initial states $|0\rangle|\downarrow\rangle$ and $|1\rangle|\downarrow\rangle$ are transformed by the CNOT gate. Sketch the Bloch sphere representation of the spin degree of freedom for each time step.

(2 Points)

d) How is the final state of the two-qubit system (after the CNOT gate) reconstructed?

(2 Points)

e) As can be seen in Fig. 2, the fidelity of the gate (number of successfull operations divided by number of operations) is far from unity. How do the authors/you explain this? Estimate the fidelity of 5 repeated gate operations on the state $|0\rangle|\downarrow\rangle$.

(1 Point)

f) Formulate a question regarding the paper or quantum computation in general that we can discuss jointly in the tutorial.

(1 Point)