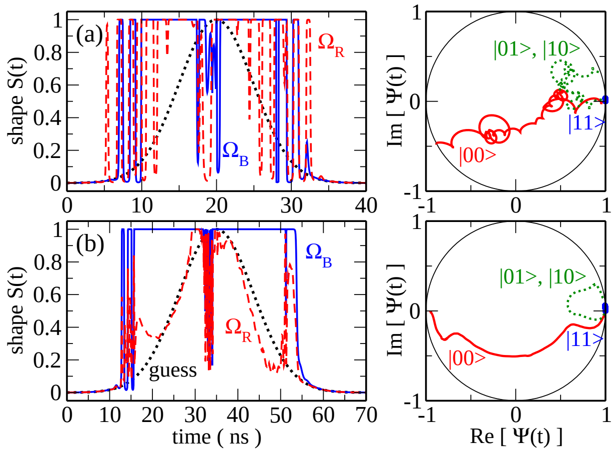
Optimal two-qubit gates for trapped neutral atoms at the quantum speed limit

Christiane Koch

Theoretische Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel

In order to realize a quantum computer within a specific physical setting, a number of criteria must be met: Roughly speaking, one needs to be able to identify quantum states to serve as qubits and carry out single and two-qubit gates as elementary computational operations. Optimal control is a versatile tool for quantum information processing since it allows for implementing a desired operation with extremely high fidelity. It can also be used to determine the minimum required gate operation time [1, 2].

In an implementation of quantum information processing based on trapped neutral atoms or molecules as qubit carriers, the main difficulty is encountered in realizing an entangling two-qubit operation such as a controlled NOT. In an optimal control approach, implementation of a CNOT gate can be achieved by maximizing the projection of the actual evolution onto CNOT as a functional of a control such as a laser field. However, for a given encoding of qubits in a physical system, it is a priori not clear whether CNOT is the two-qubit gate that can best be implemented or whether a gate that is equivalent to CNOT up to local, i.e. single-qubit, operations would be a more suitable choice. We have developed a new optimization functional that maximizes the entangling power of a desired two-qubit gate rather than the gate itself [3]. We can thus optimize for all gates that are locally equivalent to the desired two-qubit operation. We apply this new functional to the implementation of fast two-qubit gates with trapped neutral atoms and molecules.



[1] M. H. Goerz, T. Calarco, and C. P. Koch, J. Phys. B **44**, 154011 (2011)

[2] M. M. Müller, H. Haakh, T. Calarco, C. P. Koch, and C. Henkel, Quantum Information Processing in press (2011), arXiv:1104.2739

[3] M. M. Müller, D. M. Reich, M. Murphy, H. Yuan, J. Vala, K. B. Whaley, T. Calarco, and C. P. Koch, Phys. Rev. A in press (2011), arXiv:1104.2337