Quantum control of interacting qubits

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Quantum mechanics courses discuss how an initial state evolves if the Hamiltonian of the system is time-dependent. In quantum control, the question is reversed: how should the time-dependent Hamiltonian be chosen to achieve a prescribed time-dependence of the state of the system? After a general introduction, this talk will in particular address the problem of how many quantum bits of a quantum computer one needs to control to run an arbitrary quantum algorithm.

In the special case of linear arrays of qubits interacting by a Heisenberg oder anisotropic XXZ interaction, an arbitrary unitary transformation (i.e., quantum algorithm) can be generated by acting on one of the qubits at the end of the chain. In a recent theoretical study, we have determined the control sequences to implement a number of gates in small N-qubit systems (N=3 or 4) in a minimal time [1,2]. In the anisotropic case, the shortest gate times are achieved for values of the anisotropy parameter Δ larger than unity. To study the influence of possible imperfections in experimental realizations of qubit arrays, we analyze the robustness of the gate fidelities to random variations in the control-field amplitudes and finite rise times of the pulses. We also discuss applications of our results to arrays of superconducting qubits. Work done in collaboration with Rahel Heule (Basel), Daniel Burgarth (Imperial College London), and Vladimir M. Stojanovic (Basel).

[1] R. Heule, C. Bruder, D. Burgarth, and V.M. Stojanovic, Phys. Rev. A 82, 052333 (2010).

[2] R. Heule, C. Bruder, D. Burgarth, and V.M. Stojanovic, arXiv:1010.5715, accepted for publication in EPJD