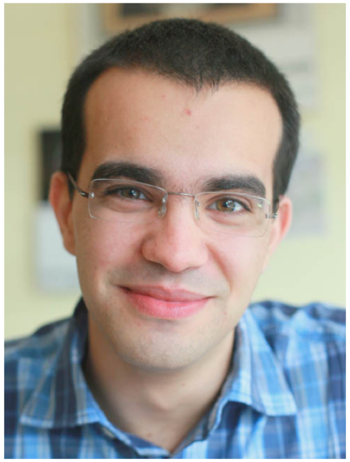
Kolloquium

Theoretische Physik

Universität Konstanz



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Mo 02.12.19
13:30 Uhr
P 603

Control of Quantum Engineered Systems with Limited Resources

Any approach to control a quantum system requires applying time-dependent control fields such that the corresponding time-dependent Hamiltonian generates the desired unitary evolution. Regardless of the setting, the generated evolution has two defining features: it must be robust against small imperfections in the amplitude, duration and phase of control pulses, and it must be fast. Unfortunately, typical approaches to generate a desired quantum evolution optimize only one of these two defining characteristics. Schemes based on quantum adiabatic evolution are typically extremely robust against parameter variations, but suffer from extremely long protocol times. In contrast, more conventional non-adiabatic approaches can be extremely fast (approaching the quantum speed limit), but require precise tuning of control pulses. In a typical experimental setting, neither approach is fully optimal, as both speed and robustness are important characteristics.

Moreover, even if one could generate a fast and robust quantum evolution, it would not necessarily mean that one generates the desired quantum evolution. The problem of coherent errors, where the quantum evolution is corrupted by populating spurious states (leakage error) or accumulates the wrong phase (phase error), is generic to a variety of situations. The most prominent example is the problem of high-fidelity qubit gates. Most physical implementations of qubits are multi-level systems, with two levels or more chosen to encode the logical states of the qubit. As a result, control sequences designed to implement a given unitary evolution can give rise to both leakage and phase errors.

I will present some of the methods put forward to generate a desired evolution and discuss their application to state-of-the-art quantum systems.