QUANTUM OPTICS SEMINAR

Title: Coherent control and quantum computing

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Abstract:

The dynamics of a quantum system driven by an external field is well described by a unitary transformation generated by a time dependent Hamiltonian. The general quantum compiler is the inverse problem of finding the field that generates a specific unitary transformation. We study this problem within the context of a quantum model composed of a large Hilbert space where only a small fraction serves to store quantum information. Specifically we study the inversion of a Fourier transform using as registers the vibrational levels of the $X^1\Sigma$ electronic state of Na_2. Raman-like transitions through the $A^1\Sigma$ electronic state induce the transitions. Using optimal control theory light fields are found that are able to implement the Fourier transform within a picosecond time scale.

Such fields can be obtained by pulse-shaping techniques of a femtosecond pulse. The implementation of the Q qubit Fourier transform in the Na_2 molecule was carried out for up to 5 qubits. The classical computation effort for implementing the quantum compiler was found to scale exponentially with the number of levels. This estimatewas based on Krotov's method for optimal control theory solving the inversion required to obtain the algorithm with a given fidelity. The resources required are related to the number of controlled interference pathways K used to construct the evolution. For low intensity K scales linearly with the product of light-field bandwidth and pulse duration. But K increases exponentially with the pulse intensity. This means that only a moderate increase in intensity is required with increase in the number of qubits.The possibility of teaching the molecule to compute via an experimentally implemented feedback algorithm is explored.

Jose P. Palao and Ronnie Kosloff, Phys. Rev. Lett., 89:188501 (2002).
Jose P. Palao and Ronnie Kosloff, Phys. Rev. A, 68:062308 (2003).

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