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**Refocusing of a Qubit System Coupled to an Oscillator.** GREGORY D. QUIROZ, LEONID P. PRYADKO, University of California, Riverside —
Within an NMR-like approach to coherent control, we analyze the performance of "soft" refocusing pulses and pulse sequences in protecting the coherence of a qubit system coupled to a quantum oscillator. We focus on the effects of the oscillator excitation and heating and associated deterioration of qubits' fidelity. These effects cannot be addressed in the conventional master equation formalism with the bath assumed in thermal equilibrium. Analytically, we construct the effective Hamiltonian of the controlled qubit plus oscillator system to quadratic order of the Magnus expansion in powers of the couplings. The qubit error operators and the terms responsible for the oscillator excitation are thus identified explicitly. These terms dominate the oscillator evolution when it is close to resonance with the qubit(s). The corresponding single- and few-qubit simulations show continuously increasing average oscillator energy accompanied by deteriorating qubit fidelity. The magnitude of the oscillator frequency bias needed to arrest this run-away effect is smaller for second-order refocusing sequences, where the order of the sequence is the number of suppressed terms in the effective Hamiltonian of the qubit system, with the oscillator operators replaced by $c$-numbers.

Gregory D. Quiroz
University of California, Riverside

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