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TITLE: Quantum algorithms for complex dynamics in presence of imperfections

ABSTRACT:

The results of analytical and numerical studies of imperfection effects for newly developed quantum algorithms for complex dynamics are presented. These algorithms allow to simulate the quantum dynamics with rich nontrivial behavior for the saw-tooth map, the wavelet kicked rotor and the Anderson metal-insulator transition. The algorithms use a polynomial number of gates O(n^2) or O(n^3) to simulate the dynamics of a vector of size O(2^n) and include as the important elements the quantum wavelet and Fourier transforms.

Already with 7 qubits they allow to study the physics of the Anderson transition in disordered solid-state systems. The numerical studies are done with up to 20 qubits. They allow to determine a law for the concurrence decay in an operating algorithm simulating the dynamics in the regimeof quantum chaos and show that the residual level of concurrence is exponentially sensitive to noise in the quantum gates.The investigations of dynamics with the multiple applications of the quantum wavelet transform determine the fidelity timescales for a large range of error amplitudes and number of qubits and imply that for static imperfections the threshold for fault-tolerant quantum computation is decreased by a few orders of magnitude compared to the case of random errors. The research is done in the frame of the EC IST-FET project EDIQIP.

The results are partially available at

1. S.Bettelli and D.L.Shepelyansky, "Entanglement versus relaxation and decoherence in a quantum algorithm for quantum chaos ", (quant-ph/0301086).

2. M.Terraneo and D.L.Shepelyansky, "Imperfection effects for multiple applications of the quantum wavelet transform ", (quant-ph/0303043 preprint).

3. A.Pomeransky and D.L.Shepelyansky, "Quantum computation of the Anderson transition in presence of imperfections" (in preparation, 2003).
