REPORT DOCUMENTATION PAGE

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quantum computing and the onset of quantum chaotic motion

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6. AUTHOR(S)
Giulio Casati

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Centro di Cultura Scientifica A Volta
Villa Olmo- Via Cantoni, 1
22100 COMO Italy

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13. ABSTRACT (Maximum 200 words)

-We have extended the theory for the statistical average of the fidelity to incorporate system-specific fluctuations. The volume of phase space that contributes to the average vanishes in the classical limit for times less than the Ehrenfest time. It is only after the Ehrenfest time that the average decay is representative for a typical initial condition.

- We have studied fidelity decay and growth of entanglement in the Jaynes-Cummings model under echo dynamics for coherent initial states. Theoretical predictions based on linear response theory and semiclassical considerations agree with numerical simulations.

We have shown that a quantum computer operating with a small number of qubits can simulate the important phenomenon of dynamical localization of classical chaos.

We are initiating an investigation on plasmon-assisted transfer of entanglement, motivated by a very recent experimental demonstration.

14. SUBJECT TERMS
Classical and quantum fidelity

15. NUMBER OF PAGES
5

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17. SECURITY CLASSIFICATION OR REPORT	18. SECURITY CLASSIFICATION ON THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
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REPORT DOCUMENTATION PAGE (SF298)
(Continuation Sheet)

1. Papers:

a)
Marko Znidaric and Tomaz Prosen,
'Fidelity and Purity Decay in Weakly Coupled Composite Systems'
submitted to J. Phys. A: Matematical and General
http://arxiv.org/abs/quant-ph/0209145

Tomaz Prosen, Thomas H Seligman and Marko Znidaric,
'Evolution of entanglement under echo dynamics'
preprint. Submitted to Phys. Rev. Lett.

G. Benenti, G. Casati, S. Montangero and D.L. Shepelyansky: "Dynamical Localization simulated on a few qubits quantum computer". Submitted to Phys. Rev. Lett.
http://arxiv.org/abs/quant-ph/0210052

P.G.Silvestrov, J. Tworzydlo, C.W.J.Beenakker
Hypersensitivity to perturbations of quantum-chaotic wave-packet dynamics
http://arxiv.org/abs/nlin.CD/0207002
submitted to Phys.Rev.Lett.

d)
P.G. Silvestrov:
"Hypersensitivity to perturbations of quantum-chaotic wave-packet dynamics",
Institute for Nuclear Theory Program on "Chaos and Interactions: from Nuclei to Quantum Dots'", University of Washington, Seattle, USA, 17 July, 2002.

I. Adagideli:
"The Loschmidt echo: The quantum/classical competition",
Institute for Nuclear Theory Program on "Chaos and Interactions: from Nuclei to Quantum Dots'", University of Washington, Seattle, USA, 17 July, 2002.

G. Casati
"Quantum computers and quantum chaos"
Institute for Nuclear Theory Program on "Chaos and Interactions: from Nuclei to Quantum Dots'", University of Washington, Seattle, USA, 17 July, 2002.

2. Scientific personnel:
Giulio Casati
Carlo Beenakker
Tomaz Prozen
Philippe Jacquod
Giuliano Benenti
Italo Guarneri

4-We have examined the role of system-specific fluctuations in the context of the "Loschmidt echo'", which measures the sensitivity to perturbation of quantum chaotic dynamics. The overlap squared of two wave packets evolving under slightly different Hamiltonians is shown to have a double-exponential initial decay in the main part of phase space. The decay rate is the self-averaging Lyapunov exponent. The average decay is single exponential with a different decay rate. The volume of phase space that contributes to the average decay vanishes in the classical limit for times less than the Ehrenfest time. It is only after the Ehrenfest time that the average decay is representative for a typical initial condition.

-We have studied stability of time evolution as characterized by the fidelity, and the decay of purity, of a reduced density matrix of a weakly coupled composite system, say a qubit array and the environment, or two parts of a qubit array.
First, we have proved a nontrivial inequality between the fidelity,the novel quantity which we named `reduced fidelity', and the purity. Reduced fidelity is defined as fidelity between reduced (environment traced) density matrices of uncoupled versus weakly coupled systems. Second, we have expressed fidelity and purity decay of composite systems (in the linar response regime of fidelity and purity close to one) in terms of time autocorrelation functions of the perturbation in each of the subsystems. The general conclusion was that enhanced chaoticity of central systems and/or environmental hamiltonian, as characterized by stronger correlation decay, increases all the three stability/entanglement measures. The theoretical predictions have been tested in a system of two coupled kicked tops. This work has been written up [new reference 1, see below] and submitted for publication.

- We have studied fidelity and purity decay (or growth ofentanglement) in the Jaynes-Cummings model (coupled harmonic oscillator and spin, e.g. atom in one mode of EM field) under the echo dynamics. We have derived explicit formulas for the case of regular classical dynamics and coherent initial states, which indicate that purity decays with classical, i.e. hbar-independent rate. Numerical results confirm theoretical predictions [new reference 2, see below].

- We have also made a progress in general semiclassical understanding of quantum fidelity decay in classically integrable systems, for the special and important case of 'ergodic' perturbation with vanishing time-average (which may often happen due to discrete symmetries).
This work is in progress and will be written up shortly.

We have studied the quantum dynamical localization for a dynamical model-the sawtooth map- using an algorithm that we have previously developed.
This algorithm has some specific advantages with respect to similar algorithms for the simulation of other dynamical systems, for instance the kicked rotator. There are no extra work space qubits, namely all the qubits are used to simulate the dynamics of the system. This implies that less than 40 qubits would be sufficient to make simulations inaccessible to present day supercomputers. We note that this figure has to be compared with the more than 1000 qubits required to the Shor's algorithm to outperform classical computations. We have also shown that in our model, dynamical localization should be observed already with 6 qubits.

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