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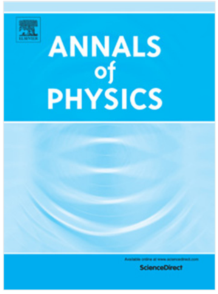

Model dynamics for quantum computing

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Model Dynamics for Quantum Computing

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A model master equation suitable for quantum computing dynamics is presented. In an ideal quantum computer (QC), a system of qubits evolves in time unitarily and, by virtue of their entanglement, interfere quantum mechanically to solve otherwise intractable problems. In the real situation, a QC is subject to decoherence and attenuation effects due to interaction with an environment and with possible short-term random disturbances and gate deficiencies. The stability of a QC under such attacks is a key issue for the development of realistic devices. We assume that the influence of the environment can be incorporated by a master equation that includes unitary evolution with gates, supplemented by a Lindblad term. Lindblad operators of various types are explored; namely, steady, pulsed, gate friction, and measurement operators. In the master equation, we use the Lindblad term to describe short time intrusions by random Lindblad pulses. The phenomenological master equation is then extended to include a nonlinear Beretta term that describes the evolution of a closed system with increasing entropy. An external Bath environment is stipulated by a fixed temperature in two different ways. Here we explore the case of a simple one-qubit system in preparation for generalization to multi-qubit, qutrit and hybrid qubit-qutrit systems. This model master equation can be used to test the stability of memory and the efficacy of quantum gates. The properties of such hybrid master equations are explored, with emphasis on the role of thermal equilibrium and entropy constraints. Several significant properties of time-dependent qubit evolution are revealed by this simple study.

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I. INTRODUCTION

A quantum computer (QC) is a physical device that uses quantum interference to enhance the probability of getting an answer to an otherwise intractable problem [1, 2]. A quantum system's ability to interfere depends on its entanglement and on maintenance of its coherent phase relations. In a real system, there are always environmental effects and also random disturbances that can cause the quantum system to lose its ability to display quantum interference. That process is called decoherence, as is discussed in an extensive literature [3] on how a quantum system becomes classical, often rapidly, due to its interaction with an external environment. That process might