Entropy production in decoherence: exactly solvable qubit models

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Entropy plays a crucial role in the theory of open quantum systems since it is a natural measure of the lack of information about a system. A problem of great interest is the time behavior of entropy in decoherence (the environment-induced destruction of quantum coherence) [1]. The simplest model systems which exhibit many of fundamental features of decoherence are two-state systems. Such systems are also important of their own right as the elementary carries of quantum information (qubits) [2].

In the "spin" representation, the entropy of a qubit can be written in the form [3]

$$S(t) = \ln 2 - \frac{1}{2}(1+v)\,\ln(1+v) - \frac{1}{2}(1-v)\,\ln(1-v),$$

where $v(t)$ is the modulus of the Bloch vector $\vec{v}(t) = \langle\vec{\sigma}\rangle^{t}$, and the components of $\vec{\sigma}$ are the Pauli matrices.

In this work the time-dependent qubit and environment entropies are calculated for some models which admit exact analytic solutions for the Bloch vector. We discuss relation between the results for the entropy production in decoherence and the Schmidt decomposition theorem for entangled quantum states [1].

1. H.-P. Breuer and F. Petruccione, The Theory of Open Quantum Systems (Oxford University Press, Oxford, 2002).

2. D. Bouwmeester, A. Ekert, and A. Zeilinger (eds.), The Physics of Quantum Information (Springer-Verlag, Berlin, 2000).

3. V.G. Morozov, S. Mathey, and G. Röpke, Phys. Rev. A **85**, 022101 (2012).