Density Matrix through Time Averaging: Decoherence and Thermalization, Adiabatic Protection

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Abstract

An approach, differing from two commonly used methods (the stochastic and the master equation), but entrenched in the traditional density matrix formalism, is developed in a semi-classical setting, so as to go from the solutions of the time dependent Schrödinger equation to decohering and thermalized states.[1] This is achieved by utilizing the time-ergodicity, rather than the sampling- (or ensemble-) ergodicity, of physical systems.

We introduce the formalism through a study of the Rabi model (a two level system coupled to an oscillator) and show that our semi-classical version exhibits, both qualitatively and quantitatively, many features of state truncation and equilibration. We then study, as an example, the time evolution of two qubits in interaction with a bosonic environment, such that the energy scale of one qubit is much larger, and that of the other much smaller than the environment's energy scale. The small energy qubit decoheres to a mixture, while the high energy qubit is protected through the adiabatic theorem. However, an inter-qubit coupling generates an overall decoherence and leads for some values of the coupling to long term revivals in the state occupations.

References

[1] R. Englman and A. Yahalom, "Partial Decoherence and Thermalization through Time-Domain Ergodicity". Phys. Rev. A **87** 052123 (2013)