Gaussian quantum discord and classical correlations of two bosonic modes in thermal environments

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Within the framework of the theory of open quantum systems based on completely positive quantum dynamical semigroups [1, 2], we give a description of the Markovian dynamics of the Gaussian quantum discord [3] for a subsystem composed of two non-interacting bosonic modes in two cases: a) they are embedded in a common thermal bath [4]; b) each mode is embedded in its own thermal bath [5, 6]. The initial state of the subsystem is taken of Gaussian form and the evolution under the quantum dynamical semigroup assures the preservation in time of the Gaussian form of the state.

We analyze the dynamics of quantum discord in terms of the covariance matrix for entangled initial squeezed thermal states. We assume that the asymptotic state of the considered open system is the Gibbs state corresponding to two independent bosonic modes in thermal equilibrium with the thermal bath. We describe the time evolution of the Gaussian quantum discord, which is a measure of all quantum correlations in the bipartite state, including entanglement, and show that it has non-zero values for all finite times, and its dynamics strongly depends on the parameters characterizing the system (squeezing parameter and damping parameter) and the coefficients describing the interaction of the system with the reservoirs (temperatures and dissipation constants): quantum discord increases with increase in the squeezing parameter and decreases with increase in the damping parameter, temperatures, and dissipation constants. The values of the Gaussian discord asymptotically decay in time under the effect of the thermal reservoirs, corresponding to the thermal product (separable) state, with no correlation at all. The evolution of the Gaussian quantum discord D is illustrated in Fig. 1, where we represent the dependence of D on time t and temperature T_2 [6].

We describe also the time evolution of classical correlations and quantum mutual information and show that they also decay asymptotically in time. In Fig. 2 we illustrate the evolution of classical correlations C as a function of time t and temperature T_2 for an initial Gaussian state, taken in the form of a two-mode squeezed thermal state. This quantity manifests a qualitative behavior similar to that of the Gaussian discord – it has nonzero values for all finite times and, in the limit of infinite time it tends asymptotically to zero, corresponding to the thermal product (separable) state, with no correlations at all. Classical correlations decrease with increase in the temperature of the thermal bath and in general their values are larger than those of quantum correlations, represented by the Gaussian quantum discord.

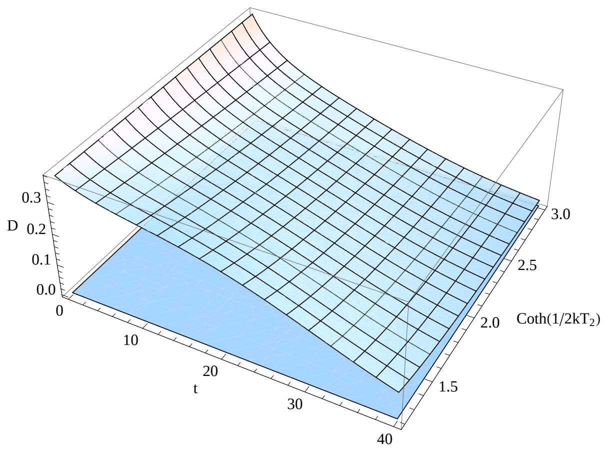

FIG. 1. Gaussian discord D versus time t and temperature T_2 (via $\coth 1/2kT_2$) for an initial squeezed thermal state [6].

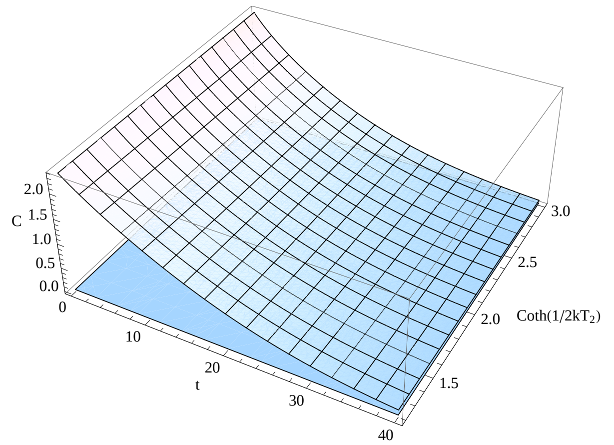

FIG. 2. Classical correlations C versus time t and temperature T_2 (via $\coth 1/2kT_2$) for an initial squeezed thermal state [6].

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[1] G. Lindblad, Commun. Math. Phys. **48**, 119 (1976).
[2] V. Gorini, A. Kossakowski, E. C. G. Sudarshan, J. Math. Phys. **17**, 821 (1976).
[3] G. Adesso and A. Datta, Phys. Rev. Lett. **105**, 030501 (2010).
[4] A. Isar, Phys. Scripta T **153**, 014035 (2013).
[5] A. Isar, Open Syst. Inf. Dynamics **20**, 1340003 (2013).
[6] A. Isar, J. Russ. Laser Res. **35**, 62 (2014).