

Gaussian discord of two-mode systems in a thermal environment from a geometric perspective

Serban Suci^{1,*} and Aurelian Isar^{1,†}

¹National Institute of Physics and Nuclear Engineering, P.O.Box MG-6, Bucharest-Magurele, Romania

In the framework of the theory of open systems based on completely positive quantum dynamical semigroups [1, 2], we address the quantification of general non-classical correlations in Gaussian states of continuous variable systems from a geometric perspective. Separable states, usually considered as being classically correlated, might also contain quantum correlations. Zurek [3] defined the quantum discord as a measure of quantum correlations of bipartite systems that can have non-zero value for separable states. It is defined as the difference between two quantum analogues of classically equivalent expressions of the mutual information, which is a measure of total correlations in a quantum state.

Gaussian geometric discord has been proposed as an intuitive quantifier of general non-classical correlations in bipartite quantum states [4]. It is defined as the minimum squared Hillbert-Schmidt distance between a bipartite Gaussian state and the closest classical-quantum Gaussian state obtained after a local Gaussian measurement on one subsystem only. Rescaled Gaussian geometric discord was introduced as an improved version of Hillbert-Schmidt geometric discord, that is not biased by the global purity of the state [5]. Recently, another geometrical formulation of quantum discord was given using the Hellinger distance [6]. In this approach the geometric discord is the minimum Hellinger distance between the given state and the set of all product states. This has the advantage that it does not require a GPOVM to be performed on one of the subsystems.

We give a description of the Hillbert-Schmidt, rescaled and Hellinger geometric discord for a system consisting of two non-interacting non-resonant bosonic modes embedded in a thermal environment. For convenience we take as initial state of the system a two-mode squeezed thermal state, but this form is not preserved in time, therefore the results are valid for all Gaussian states. By tracing the distance between our state and the closest classical-quantum Gaussian state we calculate the evolution in time of the Gaussian geometric discord under the influence of the thermal bath.

As expected, geometric discord has finite values between 0 and 1 and decreases asymptotically to 0 at large time or temperature. Unlike the entropic discord [7], the Hillbert-Schmidt geometric discord and its rescaled counterpart do not decrease monotonically in time. They have oscillations on the time axis that increase in frequency as the two bosonic modes are less resonant and their mean photon number is higher. Figure 1 shows a comparison between the entropic discord (D_E) and the three types of geometric discord: Hillbert-Schmidt (D_G), rescaled (D_τ) and Hellinger (D_H).

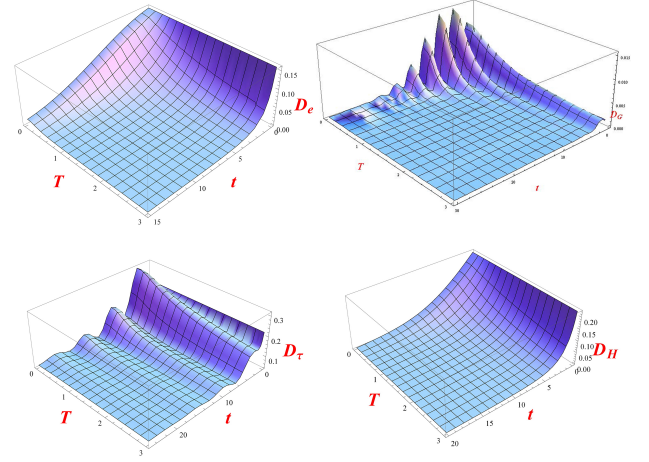


FIG. 1. Gaussian entropic discord (D_E), Hillbert-Schmidt (D_G) geometric discord, rescaled geometric discord (D_τ) and Hellinger (D_H) geometric discord versus time t and temperature T for two bosonic modes having frequencies $\omega_1 = 1$ and $\omega_2 = 0.5$, average photon numbers $n_1 = 1$ and $n_2 = 2$, damping coefficient $\lambda = 0.1$ and squeezing parameter $r = 0.5$ ($\hbar = 1$).

* serban.suciu@theory.nipne.ro

† isar@theory.nipne.ro

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