Annals of Physics 366 (2016) 1–12

Contents lists available at ScienceDirect

Annals of Physics

journal homepage: www.elsevier.com/locate/aop

Delineating incoherent non-Markovian dynamics using quantum coherence

Titas Chanda, Samyadeb Bhattacharya *

Harish-Chandra Research Institute, Chhatnag Road, Jhunsi, Allahabad - 211019, India

ARTICLE INFO

Article history:
Received 11 August 2015
Accepted 6 January 2016
Available online 12 January 2016

Keywords:
Non-Markovianity
Coherence
Open system

ABSTRACT

We introduce a method of characterization of non-Markovianity using coherence of a system interacting with the environment. We show that under the allowed incoherent operations, monotonicity of a valid coherence measure is affected due to non-Markovian features of the system–environment evolution. We also define a measure to quantify non-Markovianity of the underlying dynamics based on the non-monotonic behavior of the coherence measure. We investigate our proposed non-Markovianity marker in the behavior of dephasing and dissipative dynamics for one and two qubit cases. We also show that our proposed measure captures the back-flow of information from the environment to the system and compatible with well known distinguishability criteria of non-Markovianity.

© 2016 Elsevier Inc. All rights reserved.

1. Introduction

In recent years the study of open quantum systems has been the interest of many researchers [1–3], due to the fact that in realistic situations the system is rarely isolated and usually affected by the environment. Based on the memory effects and information flow between the system and the environment, the reduced open system dynamical processes are divided into two categories, namely, Markovian and non-Markovian dynamical maps. The Markovian dynamics of the system assumes weak system–environment interaction, short environment correlation time and as a result "memory-less" information flows between the system and the environment. It is mathematically

* Corresponding author.
E-mail addresses: titaschanda@hri.res.in (T. Chanda), samyadebbhattacharya@hri.res.in (S. Bhattacharya).

http://dx.doi.org/10.1016/j.aop.2016.01.004
0003-4916/© 2016 Elsevier Inc. All rights reserved.

described by completely positive semi-group maps, or by the solution of a master equation of the Lindblad type [1,4]. But in practice the strong coupling between system and environment generally leads to non-Markovian dynamics, where the manifestation of memory effects develops the back-flow of information from the environment to the system [5,6] and causes the breakdown of the semi-group property [7,8]. Thus Markovian maps are not always proper approximation of the underlying dynamics when dealing with many essential properties of open quantum systems, while memory effects and non-Markovianity have been shown to be a resource for quantum technologies. For example, effects of non-Markovianity have been investigated for quantum metrology [9], quantum key distribution [10], many-body physics [11], quantum teleportation [12], entanglement generation [13], optimal control [14], quantum biology [15], and channel capacity [16].

Interestingly the concept of Markovian and non-Markovian dynamics in the classical regime is properly defined and widely studied [17], but its quantum versions are somewhat ambiguous, subtle and often controversial in some sense. Thus various criteria have been proposed in recent literature to quantitatively characterize non-Markovian dynamics based on different considerations such as semi-group property, divisibility, or back-flow of information from the environment to the system etc. Based on the breakdown of semi-group property of the dynamical maps, Wolf et al. proposed a measure for non-Markovianity in terms of the deviation of the logarithm of dynamical maps from the canonical Lindblad generators [8]. Rivas et al. quantified non-Markovianity as the degree of deviation from divisibility of dynamical maps, which is commonly known as RHP measure [7]. Breuer et al. defined a measure, known as BLP measure, in terms of the non-monotonic behavior of distinguishability between different evolving states, which is associated with the back-flow of information from the environment to the system [5]. Also a number of non-Markovianity measures and witnesses have been proposed based on the non-monotonic behavior of some quantum information measures, due to nondivisibility of the completely positive and trace preserving (CPTP) maps in non-Markovian dynamics. For example, there have been significant attempts to quantify non-Markovianity using entanglement [7], quantum mutual information [18], the flow of quantum Fisher information [19], fidelity between dynamical time-evolved states [20], volume of accessible states [21], accessible information [22], local quantum uncertainty [23], quantum interferometric power [24], and total entropy production [25]. In most of these cases, computation of non-Markovianity measures requires an extra ancilla along with the system, and is complicated to calculate due to optimization problems. Also though different non-Markovianity measures have been defined based the non-monotonicity due to nondivisibility of CPTP maps, they are in general incompatible with each other [2,3,26].

In this work, we propose a method to characterize the non-Markovianity of an *incoherent* open system dynamics (IOSD) through the non-monotonic behavior of quantum coherence (QC) measures. QC is one of the foremost feature of quantum mechanics that differentiates quantum world from the classical one [27]. It possesses a wide-ranging impact on quantum optics [28], quantum information [29], solid state physics [30,31], and thermodynamics [32]. Recently a set of physical requirements has been formulated which should be satisfied by any valid measure of QC [33]. It has been also shown that any bona fide distance-based measure of QC exhibits freezing phenomena under decoherence channels for even number of qubits [34]. In parallel, the resource theory of QC is emerging as a specific field of study which is quite similar to the basic structure of entanglement resource theory [35]. Here we show that any non-monotonicity in the dynamics of a valid QC measure under an IOSD, will act as a witness of non-Markovianity. In this formalism no ancilla is needed to quantify the non-Markovian dynamics and the given measure is easy to compute even for complicated dynamics, thus making it experimentally easily tractable. We also show that this formalism is compatible with distinguishability criteria for various open system dynamics, and captures the back-flow of information from environment to the system. Also this measure is more robust compared to a non-Markovianity measure based on entanglement, which cannot qualitatively capture the back-flow of quantum information due to entanglement sudden death [36].

The paper is organized as follows. In Section 2 we briefly discuss the theory of QC from resource theory perspective and the measures of QC used in this study. In Section 3 we point out sufficient conditions for an open system dynamical map to be an IOSD and introduce a non-Markovianity measure based on the non-monotonic evolution of QC measures under an IOSD. Section 4 deals with

Download English Version:

https://daneshyari.com/en/article/1857354

Download Persian Version:

https://daneshyari.com/article/1857354

Daneshyari.com