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Spontaneous emission induced entanglement and steady entanglement in two atomic system

Huiyun XU[1] and Guohui Yang[2,*]

[1] *College of Physics and Electronics Engineering, Shanxi University, Taiyuan 030006, P.R. China*
[2] *School of Physics and Information Engineering, Shanxi Normal University, Linfen 041004, P.R. China*

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Abstract. We report possibility of generating entanglement between two atoms in free space when their spatial separation is on the order of wavelength or less. We show that these two atoms get coupled by photon exchange due to spontaneous decay, which in turn generates the atomic entanglement. By introducing the incoherent pumping, one can obtain the steady entanglement, and the incoherent pumping can overcome the decay of the atoms. Moreover, one can obtain the larger value of steady entanglement via proper tuning the incoherent pumping.

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Key words: Quantum Entanglement, Spontaneous Emission, Photon Exchange.

1 Introduction

As is well known, due to the understanding of entanglement creation and possible applications in quantum computing, quantum entanglement has attracted more attentions in the past few years. There have been many proposals for creating atomic entanglement [1–3], meanwhile some notable experimental demonstrations have also been performed. In practice, every quantum system is often constrained by unavoidable interaction with its environment, this may lead to the dissipation and destruction of entanglement [4, 5]. As a consequence, the entanglement will be zero even though the system is initially in the maximal entanglement state. In fact, apart from its traditional role of destruction of entanglement, dissipation can also create entanglement in some system [6,7].

*Corresponding author. *Email addresses:* `sxlfyghlxr@126.com` (G. H. Yang)

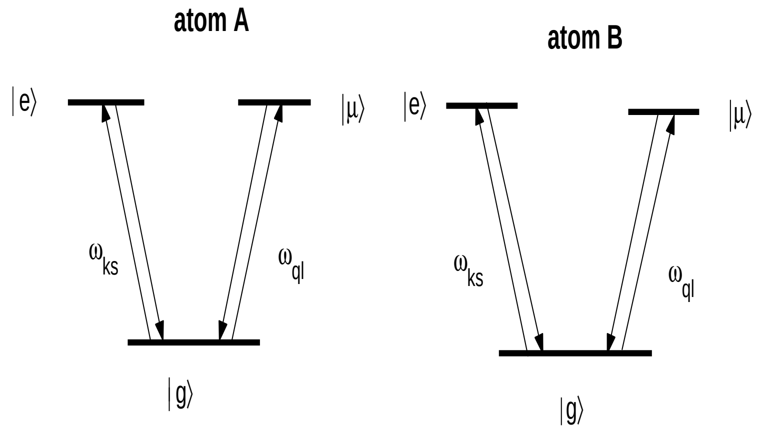

Figure 1: The atomic V-scheme and the two-atom configuration under consideration. The distance between the two atoms is considered to be small compared to the radiation wavelength.

Spontaneous emission in two-atom systems is an example of such noise which can destroy the entanglement [8]. However, beyond the conventional role of destroying entanglement, due to the possible photon exchange between atoms, the spontaneous emission also can create entanglement. In particular when the inter atomic distance is on the order of wavelength or less. It is known that a system of particles which are closer together than the relevant transition wave-length displays collective states which are immune against spontaneous emission. In this case there is a substantial probability that a photon emitted by one atom will be absorbed by the other and the photon exchange process can induce entanglement between atoms which partially overcome decoherence caused by spontaneous.

In our this paper, we extend this kind of studies to the case of pair of three-level atoms in V configuration. This system are coupled to a common thermostat at zero temperature and the reduced dynamics evolution is given by the semi-group $\{T_t\}$ of completely positive linear mappings acting on density matrices [9], this kind of dynamics takes into account only spontaneous emission and possibly photon exchange between atoms [10,11].

2 Theoretical treatment and results

We consider two identical three-level atoms in V configuration. The atoms (say A and B) have two degenerate excited states $|e\rangle_m$, $|\mu\rangle_m$ ($m=A,B$) and the ground state $|g\rangle_m$ as is shown in Fig. 1. The distance R is small compared to the radiation wavelength. At such distances there is a substantial probability that the photons emitted by one atom will be absorbed by the other. As we known, for V atomic configuration, usually the n-degenerate magnetic sublevels work as excited states. So, the dipoles in $|e\rangle_m \leftrightarrow |g\rangle_m$ and $|\mu\rangle_m \leftrightarrow |g\rangle_m$ are orthogonal to each other and also the polarization of the photon emitted