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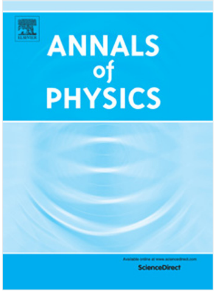

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Resonance Fluorescence and quantum interference of a single NV center

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The detection of a single nitrogen-vacancy center in diamond has attracted much interest, since it is expected to lead to innovative applications in various domains of quantum information, including quantum metrology, information processing and communications, as well as in various nanotechnologies, such as biological and subdiffraction limit imaging, and tests of entanglement in quantum mechanics. We propose a novel scheme of a single NV center coupled with a multi-mode superconducting microwave cavity driven by coherent fields in squeezed vacuum. We numerically investigate the spectra in-phase quadrature and out-of-phase quadrature for different driving regimes with or without detunings. It shows that the maximum squeezing can be obtained for optimal Rabi fields. Moreover, with the same parameters, the maximum squeezing is greatly increased when the detunings are nonzero compared to the resonance case.

Keywords: NV center; Quantum interference; Superconducting microwave cavity

I. INTRODUCTION

Nitrogen-vacancy color centers (NV centers) are point defects in the diamond lattice, which consist of a nearest neighbor pair of a substitutional nitrogen atom and a lattice vacancy [1, 2]. The detection of a single negatively charged NV-center (NV$^-$ center) in 1997 opened a new milepost in the evolution of diamond based quantum technologies [3]. The detection of a single NV center soon prompted confirmations of photostable single photon generation [4–6] and demonstrations of optical preparation and readout of NV$^-$ center electronic spin [7]. This demonstration believed that the NV$^-$ center can behaved as a solid state spin qubit suitable for quantum information processing and quantum metrology devices. Following these progress of NV$^-$ center, the studying on the NV centre and the development of its applications have been incredibly rapid. Because of its innovative features [8] in various domains of quantum information, NV$^-$ center in diamond can be used as fluorescent markers for biological systems, quantum information processing or sensing electric and magnetic fields [9–14]. Moreover, NV$^-$ center can be optically polarized and detected and exhibits excellent coherence properties even at room temperature [15].

Recently, with the technological advances in cavity quantum electrodynamics, much attention has been paid to the hybrid system that combines spin qubits of solid-state system [16, 17]. Among these hybrid systems, the composite system consisting of NV$^-$ center [9, 18, 19] has emerged as one of the most promising candidates for quantum-information applications. Despite the NV center may become a competitive candidate for solid-state quantum information processing, the excited-state structure of the defect is not yet fully understood [20, 21]. Up to now, single-spin high-speed coherent optical manipulation through Λ-based transitions [22] and quantum information protocols like quantum repeaters [23] have been accomplished.

On the other hand, the study of fluorescence spectra have been a central topic in quantum optics since the beginning era of quantum mechanics in 1930$'$s. The accurate prediction of the fluorescence spectrum under coherent excitation is a foundational success of quantum optics [24, 25]. Resonance fluorescence of atoms interacted with coherent fields take on a number of interesting quantum features of the electromagnetic field, such as photon antibunching [26] and sub-Poissonian photon statistics [27]. In contrast to fluorescence spectra which are detected without phase sensitivity, squeezing spectra are obtained by homodyne detection of scattered radiation from free atoms driven by a coherent field [28]. Resonance fluorescence of atomic interactions with squeezed light can also have potential application to enhance measurement precision in applications ranging from gravitational wave detectors [29] to biological imaging [30]. Traditionally, squeezing in fluorescence spectrum are mainly produced in atomic system interacted with external fields [28, 31–33]. In spite of receiving considerable attention, squeezing in resonance fluorescence has eluded experimental observation, the main challenge is that atomic motion causing phase shifts destroy squeezing [34]. With the development of new quantum technology, some artificial atoms, such as quantum dots, superconducting qubits or NV centers may be solve this problem. Recently, the circuit quantum electrodynamics architecture has emerged as

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