QUANTUM NONDEMOLITION MEASUREMNT BASED ON DOUBLE-EIT INDUCED STATIONARY LIGHT

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Since quantum mechanics was applied for a quantum protocol which could transport a quantum state from one location to another, great attention has been drawn in quantum information and communications [1]. During the last decade there has been much progress in quantum information science such as entanglement generations, single photon generations, quantum key distributions, quantum universal gate operations, and quantum teleportation. Unlike classical information processing, any measurement on the quantum information could destroy it. Therefore, on-demand quantum measurement has been intensively studied for quantum error corrections for practical quantum information science. So far the most advanced technique of the quantum measurement is based on nonlinear optics in which strong interactions are inevitable and may negatively affects on the quantum information status.

Electromagnetically induced transparency (EIT) is a quantum optical phenomenon of showing nonabsorption resonance in an optically dense medium. The induced transparency is a direct result from refractive index change due to destructive atom-field interactions. Most interesting aspects of EIT is in its nonlinear quantum applications such as slow light propagations, quantum memory, quantum switch, entanglement generations, and Schrodinger cat state generation [2]. Very recently, Lukin's group succeeded to trap a weak optical field in an optically dense medium by using standing wave grating based on EIT [3]. The stationary light trapped in the optical medium is very important for nonlinear quantum optics because the interaction time can be arbitrarily controllable by adjusting the grating time which is limited by spin coherence decay time of the medium. Thus, nonlinear effects can be greatly enhanced even with a single photon.

In this paper, we propose an on-demand quantum measurement technique based on stationary lights. Unlike the stationary light based on the standing optical waves, we propose a generalized light trapping based on coherence gratings in a double-EIT scheme [4]. A double-EIT scheme was used for signal amplifications in 1995 by Hemmer's group, and recently Harris' group analyzed it for both signal EIT and four-wave mixing signal amplifications. In our double-EIT scheme, we numerically demonstrate that both probe field and the phase conjugate with counter-propagation can be trapped by coherence gratings on spin transitions owing to counterpropagating coupling fields. Under the action of the coherence moving gratings, the trapping time of both signal and the phase conjugate field can be controlled without losing nonabsorption phenomenon if a certain condition is satisfied. The photon trapping phenomenon based on coherence grating can be applied for quantum nondemolition measurement owing to on-demand controllable interaction time even with a single photon. We propose a suitable scheme for the quantum nondemolition measurement. This work was supported by Korea Research Foundation Grant KRF-2003-070-C00024.

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