Quantum storage based on the control field angular scanning

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Optical quantum memories are usually assumed to store and recall optical pulses, such as single-photon wave packets, exploiting inhomogeneous broadened transitions (tailored or controlled) or modulated control fields [1]. Recently we suggested a different approach which requires neither inhomogeneous broadening nor temporal modulation of the control field amplitude, but resorts to continuous phase-matching control (PMC) in an extended resonant medium [2, 3]. We consider off-resonant Raman interaction of a single-photon wave packet and a classical control field in a three-level atomic medium. A basic idea is to reversibly map a single photon state into a superposition of atomic collective excitations (spin waves) with different wave vectors via continuous change of the wave vector of the control field during the interaction. PMC may be implemented by three different methods, namely, by the modulation of the refractive index [2], the angular scanning [3], and the frequency chirp of the control field. This talk is focused on the second method based on continuous change of the propagation direction of the control field. We show that under some conditions, the proposed method is mathematically analogous to the quantum storage via longitudinal controlled reversible inhomogeneous broadening (CRIB) scheme. Figure 1 shows the dependence of the efficiency and fidelity on the average polar angle θ₀ made by the control and signal wave vectors.

![Graph](image)

Figure 1. Forward retrieval (a) Efficiency η and (b) Fidelity F' v.s. the average polar angle θ₀ with the rotation angle Δθ of the control wave vector being kept as constant.

This method has a number of advantages: 1) as the same as longitudinal CRIB, high efficiency can be achieved without backward retrieval; 2) it does not require a preparation of a narrow spectral peak in the ground state population, which results in a higher efficiency for the same number of atoms in the ensemble; 3) it does not require a direct control of atomic levels, thus potentially reducing decoherence; 4) its implementation does not require either the presence of the Stark or Zeeman effects.