Pilna energijos konversija tarp orbitinį judesio kiekio momentą pernešančių lazerio pluoštų taikant koherentinį populiacijos pagavimą dvigubos-Λ atomų-šviesos sąveikos schemoje

Complete energy conversion between light beams carrying orbital angular momentum using coherent population trapping for a coherently driven double-Λ atom-light-coupling scheme

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The interaction of coherent light with atomic systems allows observation of several important and interesting quantum interference effects such as coherent population trapping (CPT) [1], electromagnetically induced transparency (EIT) [2], and stimulated Raman adiabatic passage (STIRAP) [3]. These phenomena are based on the coherent preparation of atoms in a so-called dark state which is immune against the loss of population through spontaneous emission.

A light beam can carry orbital angular momentum (OAM) due to its helical wave front [4]. Such a light beam with the spiral phase has an optical OAM. The phase singularity at the beam core of the twisted beam renders its donut-shaped intensity profile. A number of interesting effects appear when this type of optical beam interacts with atomic systems. Among them optical vorticities of slow light [5, 6] have generated considerable interest, as the OAM brings an additional degree of freedom in the manipulation of the optical information during the storage and retrieval of the slow light.

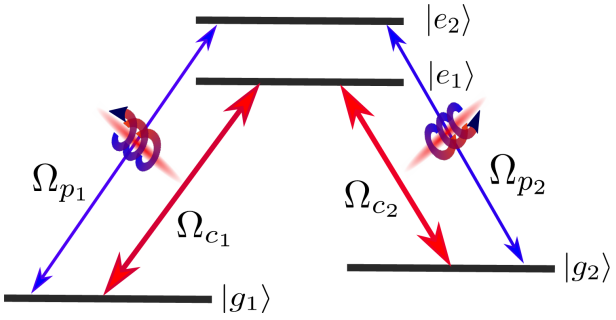

Fig. 1. Schematic diagram of the double-Λ atomic system.

We propose a procedure to achieve a complete energy conversion between laser pulses carrying orbital angular momentum (OAM) in a cloud of cold atoms characterized by a double-Λ configuration of the atom-light-coupling scheme (Fig. 1.), described by the atomic Hamiltonian

$$H = -\Omega_{p_1}|e_2\rangle\langle g_1| - \Omega_{p_2}|e_2\rangle\langle g_2| - \Omega_{c_1}|e_1\rangle\langle g_1| - \Omega_{c_2}|e_1\rangle\langle g_2| + \text{H.c.} \qquad (1)$$

A pair of resonant spatially dependent control fields with Rabi frequencies Ω_{c_1} and Ω_{c_2} prepare atoms in a position-dependent coherent-population-trapping [1] state, while a pair of much weaker vortex probe beams (Rabi frequencies Ω_{p_1} and Ω_{p_2}) propagate in the coherently driven atomic medium. Using the adiabatic approximation we derive the propagation equations for the probe beams. We consider a situation where the second control field is absent at the entrance to the atomic cloud and the first control field goes to zero at the end of the atomic medium. In that case the incident vortex probe beam can transfer its OAM to a generated probe beam.

We show that the efficiency of such an energy conversion approaches the unity under the adiabatic condition. On the other hand, by using spatially independent profiles of the control fields, the maximum conversion efficiency is only ½ [7].

Keywords: Orbital angular momentum, Double Lambda atomic system, Coherent population trapping

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