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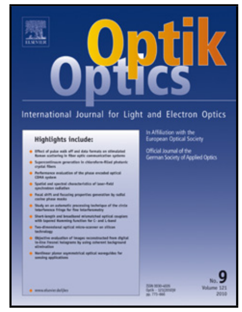

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SEPARATION OF SPIN AND ORBITAL ANGULAR MOMENTUM STATES FROM CYLINDRICAL VECTOR BEAMS

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Abstract: Cylindrical vector beams namely, radially polarized (RP) and azimuthally polarized (AP) light beams with inhomogeneous polarization distributions can be written as superposition of homogeneously polarized beams, each beam having opposite spin and orbital angular momentum (OAM) components. In this paper we describe the experimental extraction of any one or both of the angular momentum states by appropriate polarization selection. Since there are two spin angular momentum (SAM) states and two OAM states present in a single beam, the use of such beams in quantum computing is an attractive option. It is also possible to switch polarity of either their spin or orbital angular momentum and therefore quite suitable for applications in the field of free space optical communication.

Keywords: Optical vortices; Singular optics; Polarization; Quantum computing; Optical communication

1. Introduction: Phase singular beams also known as optical vortex beams carry OAM. Optical vortex corresponds to a wave with helical phase structure with the phase singular point at the center causing an intensity null at that point [1-2]. The accumulated phase change around the singular point in a closed loop must be integral multiple of 2π given by $2\pi l$, where l is called the topological charge of the vortex beam. The OAM [3-5] carried by each photon is equal to the integral multiple of Planck's constant $(\pm l\hbar)$. Besides this photons also carry SAM associated with their polarization handedness. A circularly polarized beam carries SAM [6] of magnitude $\pm\hbar$ per photon, where $\pm$ correspond to two different polarization handedness. In the last few years, cylindrical vector (CV) beams [7-9] having inhomogeneous polarization distribution (e.g. RP and AP beams) across its cross-section are widely explored due to their unique characteristics [10-15]. CV beams are the axially symmetric beam solution of full vector wave equation and can be generated by various active and passive methods [16-21]. There have been a lot of efforts by the research community in recent years, to find different methods for generating and controlling the charge of the optical vortices. The most common methods use spatial light modulator (SLM), optical fiber, vortex plate for vortex beam generation [22-25]. Apart from generation, separation of OAM states of light from optical fields is also important. Computational methods such as Helmholtz-Hodge decomposition [26] and circular harmonic decomposition [27,28] can be employed for OAM separation from arbitrary beams. CV beam contains four different angular momentum states and two types of phase defects, namely point and edge phase defects. It has been seen that on decomposition of a RP/AP CV beam into two orthogonal SAM states, both the states has a point phase defect at their center [9]. On the other hand, if we decompose a RP/AP CV beam into two orthogonal linearly polarized states, we get a line phase defect passing through the center of each decomposed component. Therefore, the nature of the phase defect depends on which of the polarization component of the CV beam is looked into [9].

In this work, it is experimentally shown that any of the constituent OAM and SAM states of a RP/AP beam can be separated from the original beam by a combination of two quarter waveplates and a rotating polarizer. Further it is explained that by replacing the polarizer with a polarizing beam splitter and an additional quarter waveplate, the constituent OAM and SAM states of the CV beam can be simultaneously separated which is an advantage in terms of simplicity over other methods [29-32]. Since there are two SAM states and two OAM states present in a single beam, the use of such beams in quantum computing [33] is an attractive option. Control of OAM is also an essential operation required in optical communication [34].