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Optical Vortex in Asymmetric Arcs of Rotating Intensity

Authors : Mona Mihailescu, Rebeca Tudor, Irina A. Paun, Cristian Kusko, Eugen I. Scarlat, Mihai Kusko

Abstract : Specific intensity distributions in the laser beams are required in many fields: optical communications, material processing, microscopy, optical tweezers. In optical communications, the information embedded in specific beams and the superposition of multiple beams can be used to increase the capacity of the communication channels, employing spatial modulation as an additional degree of freedom, besides already available polarization and wavelength multiplexing. In this regard, optical vortices present interest due to their potential to carry independent data which can be multiplexed at the transmitter and demultiplexed at the receiver. Also, in the literature were studied their combinations: 1) axial or perpendicular superposition of multiple optical vortices or 2) with other laser beam types: Bessel, Airy. Optical vortices, characterized by stationary ring-shape intensity and rotating phase, are achieved using computer generated holograms (CGH) obtained by simulating the interference between a tilted plane wave and a wave passing through a helical phase object. Here, we propose a method to combine information through the reunion of two CGHs. One is obtained using the helical phase distribution, characterized by its topological charge, m. The other is obtained using conical phase distribution, characterized by its radial factor, r0. Each CGH is obtained using plane wave with different tilts: km and kr for CGH generated from helical phase object and from conical phase object, respectively. These reunions of two CGHs are calculated to be phase optical elements, addressed on the liquid crystal display of a spatial light modulator, to optically process the incident beam for investigations of the diffracted intensity pattern in far field. For parallel reunion of two CGHs and high values of the ratio between km and kr, the bright ring from the first diffraction order, specific for optical vortices, is changed in an asymmetric intensity pattern: a number of circle arcs. Both diffraction orders (+1 and -1) are asymmetrical relative to each other. In different planes along the optical axis, it is observed that this asymmetric intensity pattern rotates around its centre: in the +1 diffraction order the rotation is anticlockwise and in the -1 diffraction order, the rotation is clockwise. The relation between m and r0 controls the diameter of the circle arcs and the ratio between km and kr controls the number of arcs. For perpendicular reunion of the two CGHs and low values of the ratio between km and kr, the optical vortices are multiplied and focalized in different planes, depending on the radial parameter. The first diffraction order contains information about both phase objects. It is incident on the phase masks placed at the receiver, computed using the opposite values for topological charge or for the radial parameter and displayed successively. In all, the proposed method is exploited in terms of constructive parameters, for the possibility offered by the combination of different types of beams which can be used in robust optical communications.

Keywords : asymmetrical diffraction orders, computer generated holograms, conical phase distribution, optical vortices, spatial light modulator
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