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Vortex axicons for hypergeometric beams formation

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Abstract

A method for obtaining multi-ring distributions by using combinations of diffractive optical elements (DOE) for the formation of hypergeometric (HG) vortices is described. The calculated vortex axicons form a superposition of two HG vortices due to a combination of two logarithmic axicons in the phase function. Experimental results on the optical capture and transport of polystyrene microparticles with a diameter of 5 μm using calculated DOEs are presented.

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Keywords: hypergeometric beam; axicon; diffractive optical element; light beam; intensity distribution; superposition of vortex beams

1. Introduction

HG modes, like Bessel ones, find application in problems of an optical micromanipulation for motion [1] and rotation of microbiological objects [2], and also in micromechanical systems. The most used Bessel beams [3], Laguerre Gauss modes [4] and diffractive optical elements [5, 6] are used for this purpose. HG modes allow get a larger torque in comparison with Bessel beams. It is also possible to vary distribution of HG beams intensity depending on problems of an optical micromanipulation. On the basis of HG modes Gauss HG beams [7] which can be formed experimentally by means of holograms synthesized on a computer [8] were obtained.

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HG beam can be formed by means of binary logarithmic axicon [9, 10]. In work [11] the method of light fields generation is proposed. The light fields are a superposition of several vortex light beams which are formed by vortex axicons. In current work, formation of HG functions superposition in which topological charges of structure and zones add together is described. Distribution of their intensity represents a group of light rings of approximately equal intensity that naturally solves the problem.

2. Vortex axicons with phase logarithmic distribution in a zones

We consider a vortex axicon [11]. The element from [11] is a union of two logarithmic axicons that have different topological charges in different zones of the axicon expansion. So in Fig. 1 superposition of two modes with identical charges 1 is presented. As phase function on an element is turned on π, these modes is propagated with phase shift. At the same time topological charges of the structure and zones are added. It allows to regulate an inclination of a wave front at the given structure of rings that is very useful in a problem of optical rotation of micro objects.

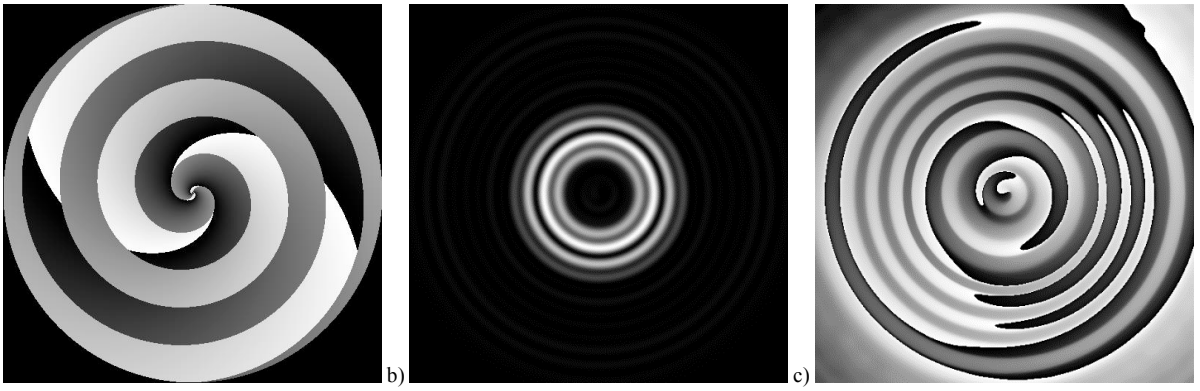

Fig. 1. DOE phase function of a beam with topological charges for formation of light beams superposition with topological charges- 2 for structure and 1 for zones (a), intensity distribution in Fresnel diffraction (b), a beam phase (c).

In Fig. 2 one more example of such element behavior – superposition of two HG modes with identical charges 5 is presented. As a matter of convenience a topological charge of structure is zero. In this case the system of rings with a vortex of the fifth order is formed.

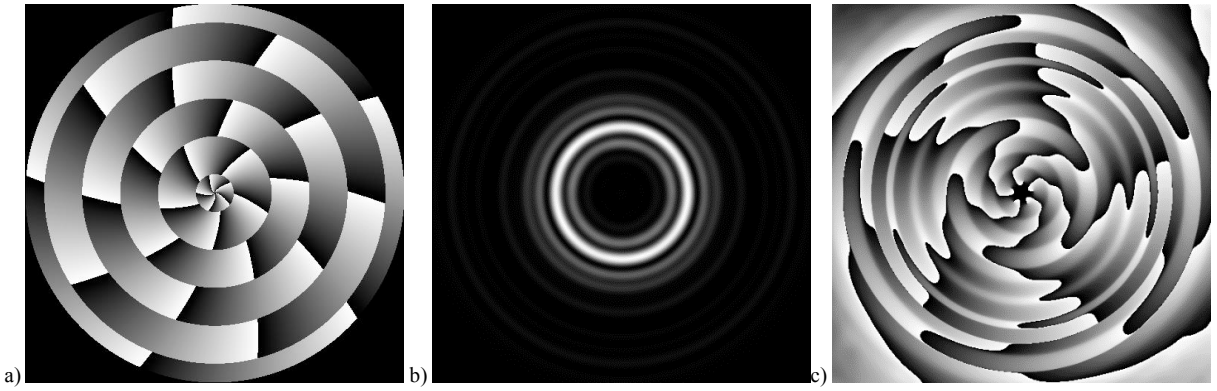

Fig. 2. DOE phase function for the formation of a superposition of light beams with topological charges 0, 5 (a), intensity distribution of the Fresnel diffraction pattern (b), a beam phase (c).