Modeling curvilinear diffraction gratings for generating optical vortices

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Introduction

Spiral phase plates [1], helical axicons [2], and other optical elements [3] can be used to generate optical vortex (OV) beams along the optical axis. In some applications, it is necessary to simultaneously form several OV beams of different orders. For this purpose, fork gratings and multi-order diffractive optical elements are used [4]. In "curved fork" gratings [5, 6], the phase of the vortex is consistent not only with the linear carrier component deflecting the beam at an angle to the optical axis, but also with the conical wave front. Such gratings were used to form Bessel vortex beams.

In this work, the problem was set to simulate the generation of vortex conical beams using a binary curvilinear gratings.

Simulation

Consider a phase-optical element with a transfer function of the following type [6]:

$$\tau(r,\varphi) = e^{i\alpha r + im\varphi} e^{i\beta r\cos(\varphi)}, r < R \quad (1)$$

where $e^{i\alpha r + im\varphi}$ – spiral axicon forming the m-order of the Bessel Vortex Beam; $e^{i\beta r\cos(\varphi)} = e^{i\beta x}$ – prismatic component corresponding to a linear carrier deflecting the beam from the optical axis.

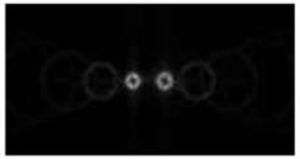
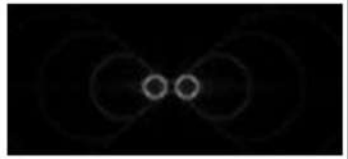
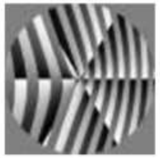
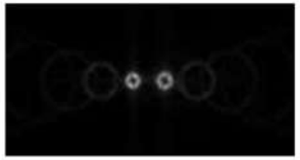
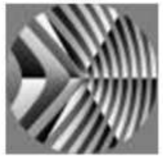
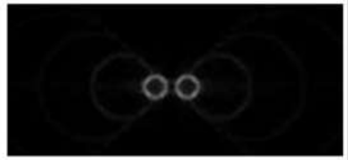
Further, for modeling, we will use a binary analogue of the diffractive element defined by the equation (2):

$$\tau(r,\varphi) = e^{i\frac{\pi}{2}(sgn[\cos(\alpha r + \beta r\cos(\varphi) + m\varphi)] - 1)}, r < R. \quad (2)$$

Let's create a set of vortex conical beams. During simulation, an element (radius R = 1 mm) with a transfer function determined by equation (1), supplemented by a lens with a focus f = 800 mm, was illuminated by a flat laser beam with a wavelength $\lambda = 532$ nm.

Table I shows the results of modeling the generation of vortex conical beams using a binary curvilinear lattice defined by equation (2) withe parameters: $m = 1$, $\beta = 30\ mm^{-1}$, $\alpha = 10\ mm^{-1}$ and $\alpha = 20\ mm^{-1}$.

TABLE I. RESULTS OF MODELING THE GENERATION OF VORTEX CONICAL BEAMS USING A BINARY CURVILINEAR LATTICE

	Input field phase $\tau(r,\varphi)$	FT amplitude		Input field phase $\tau(r,\varphi)$	FT amplitude
$\alpha = 10\ mm^{-1}$	m=0 		$\alpha = 20\ mm^{-1}$	m=0 	
	m=1 			m=1 	

Conclusion

The results of modeling the generation of vortex conical beams using a binary curvilinear lattice are demonstrated. The possibility of forming a pair of ideal optical vortices with variable parameters is shown.

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