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LAGUERRE – GAUSSIAN BEAMS IN OPTICAL COMMUNICATIONS

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The recent years have seen an increased interest in optical wireless communications. It’s also known as fiber-free optics, a technology that transports data via laser beams [1]. The latest studies have shown that employing Laguerre – Gaussian (LG) beams in optical wireless communications will improve the communication quality [2]. The LG modes are rotationally-symmetric fields that form an orthogonal basis set. They carry $m\hbar$ quanta of orbital-angular momentum (OAM) per photon. The OAM modes have been broadly applied to enhancing transmission rates of both classical and quantum communications [3]. To increase the capacity of a free space optical communication system mode-division multiplexing technology can be used, in which multiple LG beams can be efficiently multiplexed and propagate [4].

In this paper, we numerically study the propagation of a Laguerre–Gaussian beam in a free space, to visualize the beam structure during propagation. The modeling is performed using the Fresnel transform.

As an input field, we considered the LG mode in case of $z = 0$. It can be expressed as follows:

$$_{mn}(r,\varphi) = \frac{1}{w_0}\sqrt{\frac{2n!}{\pi(n+|m|)!}}\exp\left(\frac{-r^2}{w_0^{\,2}}\right)\times\left(\frac{\sqrt{2}r}{w_0}\right)^{|m|} L_n^{m\vee}\left(\frac{2r^2}{w_0^{\,2}}\right)\exp[+im\varphi],$$

where w_0 is the waist radius; n,m are integers; $L_n^{m\vee}$ is generalized Laguerre polynomial.

The intensity distribution of the LG beam can be determined as an absolute value of the complex amplitude and the phase distribution as taking the angle of it in the complex plane. The results of modeling can be seen in Figure 1.

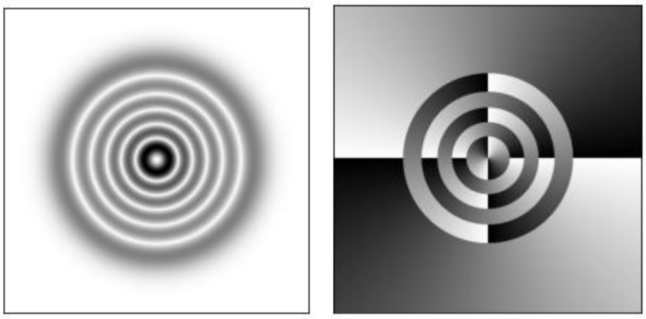

Fig. 1. The intensity and the phase distribution of the LG beam (n,m) : $(5,2)$, $w_0 = 0.391$ mm, the size of the field in the input area is 2×2 mm

The propagation of LG modes can be modeled using the Fresnel transform. It is a diffraction integral, enables to calculate the intensity and the phase distribution of the beam at the various distances z. The results have shown that LG modes preserve their structure up to a scale during propagation (Fig. 2, 3).

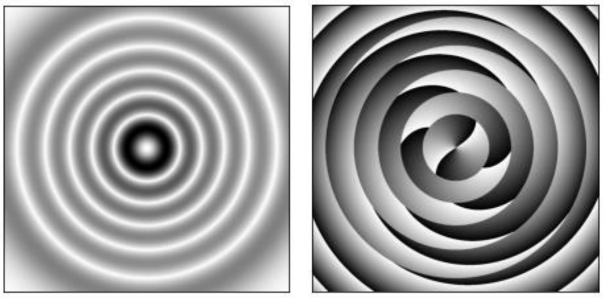

Fig. 2. Propagation of the LG mode in free space (n,m): $(5,2)$, $w_0 = 0.391$ mm, $z = 1000$ mm, the size of the field in the input area is 2×2 mm. The intensity and the phase distribution

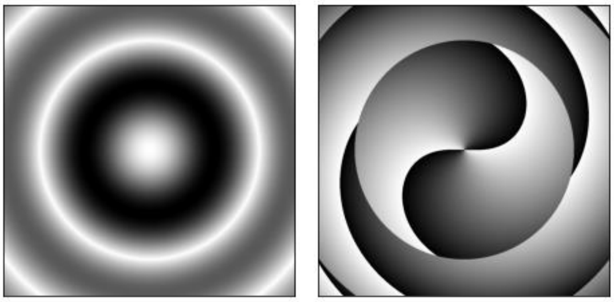

Fig. 3. Propagation of the LG mode in free space (n,m): $(5,2)$, $w_0 = 0.391$ mm, $z = 4000$ mm, the size of the field in the input area is 2×2 mm. The intensity and the phase distribution

In the present paper we have studied the standard LG beams. We have modeled the propagation of these modes in a free space using Fresnel transform. It has been shown that LG beams preserve their structure up to a scale during propagation.

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