Generation of Optical Beams with Fractional Orbital Angular Momentum

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Abstract: We experimentally generate optical beams containing a custom value of orbital angular momentum (OAM) with the freedom of shaping its transverse intensity distribution without affecting its OAM. The method relies in defining creation operators in the Fourier domain, whose angular and radial parts can be adjusted to shape the intensity pattern. By using this analytical procedure, we can able to generate with a spatial light modulator paraxial and nondiffracting beams containing fractional OAM and different intensity distributions.

1. Introduction

Optical beams with fractional values of OAM can be generated in several ways. A method was proposed by Martinez-Castellanos and Gutierrez-Vega [1]. They developed a procedure to shape an optical beam with a particular value of OAM but allowing the flexibility of shaping the transverse intensity distribution, without changing its OAM. Following [1], we can determine the OAM carried by a beam with complex amplitude $U(r, z)$ using the following expression:

$$J_z = \frac{\iint |U_0|^2 A^* \partial_\phi A \, d\mathbf{k}}{i \, \iint |U_0|^2 |A|^2 \, d\mathbf{k}} .$$

Here, U_0 is an auxiliary seed beam which does not contain OAM, and $A(k_x, k_y)$ is the Fourier representation of the creation operator $\hat{A}$ that shapes the seed beam to generate U, *i.e.* $U = \hat{A}U_0$. Using this equation for J_z, we can generate a beam with the value of OAM by selecting the adequate operator A. Furthermore, we can adjust the seed beam to shape the transverse pattern of U while keeping the OAM constant.

2. Results

In this work, we show experimental results to validate the procedure proposed in reference [1]. Figure 1 shows the results when the seed beam is either a Bessel beam or a Laguerre-Gauss beam. The beams are generated using a spatial light modulator and the intensity pattern is measured with a CCD camera.
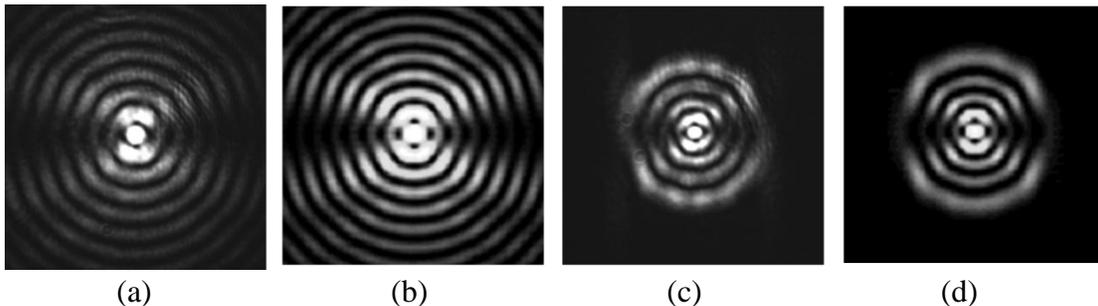

(a)   (b)   (c)   (d)

Fig. 1. Experimental [(a) and (c)] and numerical results [(b) and (d)] for beams carrying OAM equal to $J_z = 0.7$. In (a) and (b) the seed beam is a nondiffracting Bessel beam and, in (c) and (d) the seed beam is a Laguerre-Gauss beam.

3. References

[1] Israel Martinez-Castellanos, Julio C. Gutiérrez-Vega "Shaping optical beams with non-integer orbital-angular momentum: a generalized differential operator approach," Opt. Lett. **40**, 1764, (2015).