Direct Observation of Helical-Conical Wavefronts in Structured Beams

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Abstract: We show that there are two traveling waves that constitute the family of Laguerre-Gauss beams, which we call the incoming and the outgoing wave. Both traveling waves are characterized by a conical wavefront and, in addition, a helical phase when the azimuthal index is different from zero. We generate Laguerre-Gauss beams using a spatial light modulator and measure their helical and conical wavefronts using a Shack-Hartmann sensor. This description in terms of conical wavefronts is helpful to understand some beam properties such as self-healing.

1. Introduction

The orbital angular momentum contained in Laguerre-Gauss beams and its behavior and features have great importance for many applications nowadays. Having and understanding the fundamental features at their minimal parts, it can reveal information for new people or even experts in the field. We consider that the transverse intensity in a LG beam is stationary and constituted by two traveling waves, the incoming and outgoing waves [1]. The transverse structure in a LG beam is given by

$$\mathrm{LG}_{m,n}(r,\phi) = C_{m,n}\,(r/w_0)^{|m|}\exp(-r^2/w_0^2)\,L_n^{|m|}(2r^2/w_0^2)\exp(-im\phi), \qquad (1)$$

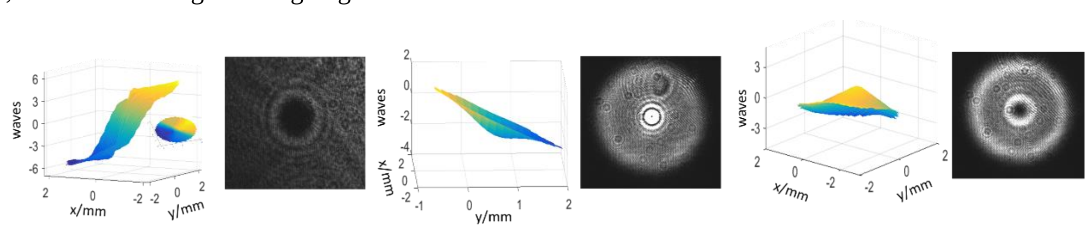
where $L_n^{|m|}$ is the associated Laguerre Polynomial, which can be written as

$$2L_n^{|m|} = HL_{in} + HL_{out} \text{ where } HL_{in} = \left(L_n^{|m|} + iX_n^{|m|}\right);\ HL_{out} = \left(L_n^{|m|} - iX_n^{|m|}\right) \qquad (2)$$

$HL_{in,out}$ are the Hankel-Laguerre functions and $X_n^{|m|}$ is the second solution to the Laguerre differential equation [1]. In some cases, this description helps to understand the self-healing property of the beams, as shown in [2]. We can observe the conical and helical wavefronts by changing HL_{in} or HL_{out} in equation (1), and measure only $\exp(-im\phi)$ for the helical part.

2. Results

We generate the beams with a spatial light modulator and measure the wavefront with a Shack-Hartmann sensor as in [3]. Simultaneously, we measure the intensity distribution using a CCD camera. Figure 1 shows the helical wavefront for m=4, and the incoming and outgoing waves that constitute the LG beam.



(a) (b) (c)

Fig. 1. Wavefront and intensity distributions that constitute of LG beams. (a) Helical, (b) incoming conical, and (c) outgoing conical.

4. References

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