Multi-channel waveguides induced by Bessel beams in a photorefractive medium

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***Abstract*— We numerically investigate the propagation and interaction of Bessel beams in a photorefractive (PR) nonlinear medium. By varying Bessel beam parameters and the PR nonlinearity, complex multi-channel structures can be photo-induced by single or two counter-propagating (CP) Bessel beams. These results pave the way towards all-optical interconnects.**

***Keywords*— Bessel beam; Photorefractive nonlinear medium; Complex photo-induced waveguide; Optical interconnects**

I. INTRODUCTION

Recent studies show that unconventional Airy beams permit the photo-inscription of complex waveguides under different nonlinear effect, for example the photorefractive effect based on the Pockels effect [1-2]. Such waveguides, resulting from the multi-lobes and peculiar characteristics of Airy beams, present multiple input/output structures more interesting than those induced by classical Gaussian beams. Bessel beams share similar propagating properties with Airy beams, such as diffraction-free in a linear medium, and self-trapping in a nonlinear medium [3]. In this work, we focus on the propagation and interaction of Bessel beams in a photorefractive (PR) nonlinear medium. By varying the Bessel beam parameters and the PR nonlinearity, it is possible to create various complex waveguides with multiple addressable inputs/outputs.

II. NUMERICAL MODEL AND RESULTS

The numerical model describing the propagation of the counter-propagating (CP) Bessel beams in a PR medium is presented as follows: $i\partial_Z F+\partial^2_X F = \Gamma E_0 F$, $-i\partial_Z B+\partial^2_X B = \Gamma E_0 B$, where F and B represent respectively the forward (+z) and backward (-z) beams, Γ is the PR nonlinearity and E0 is the PR space charge field.

A. Waveguides induced by a single Bessel beam

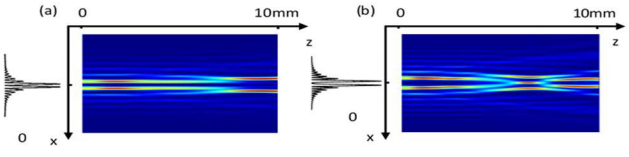

Fig. 1. (a) Intensity distribution of a single first order Bessel beam for Γ=5. (b) Intensity distribution of a single second order Bessel beam for Γ=5.

Figure 1 shows the intensity distribution of one single Bessel beam propagating in the PR nonlinear medium. The variation of the refractive index under Pockels effect forms multi-channels waveguides whose profiles correspond to the patterns in Fig. 1. As shown in Fig. 1b, we see that the waveguides induced by higher order Bessel beam may give access to two, three or even four inputs/outputs.

B. Waveguides induced by two counter-propagating Bessel beams

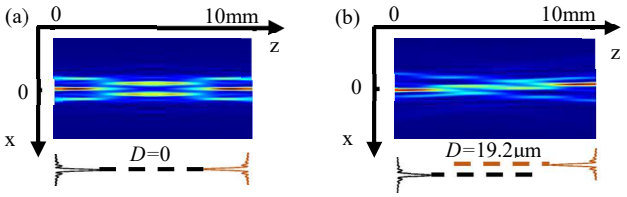

Fig. 2. (a) Intensity distribution of two aligned zero order Bessel beam (D=0) for Γ=4. (b) Intensity distribution of two CP zero order Bessel beam with the shifting distance D=19.2μm for Γ=3.

As shown in Fig. 2 (a), a multiple inputs/outputs waveguiding structure is induced by two aligned CP Bessel beams. Moreover, Fig. 2 (b) shows that when two misaligned CP Bessel beams are injected, their lobes merge and reorganize themselves in the PR medium and induce a more complex multi-channels structure with a large possible shift between the different inputs/outputs.

III. CONCLUSION

In conclusion, compared to analog configurations using Airy or Gaussian beams, by changing the Bessel beam order, shifting the distance between the two CP beams, adjusting the nonlinearity of the PR medium, more complex waveguides with multiple inputs/outputs structures and wider transverse shifts can be induced. These results provide a useful paradigm for new optical communication and information processing.

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