Complex Optical Waveguiding Structures Induced By Bessel Beams

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The propagation and interaction of unconventional Airy beams in nonlinear media permits the creation of multiple photo-induced waveguiding structures which are interesting for the development of all-optical interconnects [1,2]. Such complex light-induced structures, different from those induced by Gaussian beams, result from the unique profiles and peculiar characteristics of Airy beam (diffraction-free, self-healing). Bessel beams share similar features with Airy beams and have been studied in the past and recent years for example in a self-focusing nonlinear medium [3,4] where soliton-like, breathing and self-trapping properties have been observed. However, the studies are limited only to a single Bessel beam in a quadratic electro-optic response, and nonlinear interactions of Bessel beams is not studied.

In our work, we are interested in generating complex waveguiding structures induced by Bessel beams in a photorefractive nonlinear medium. By varying the Bessel beams parameters and the nonlinearity, multiple complex light-induced waveguiding structures are observed.

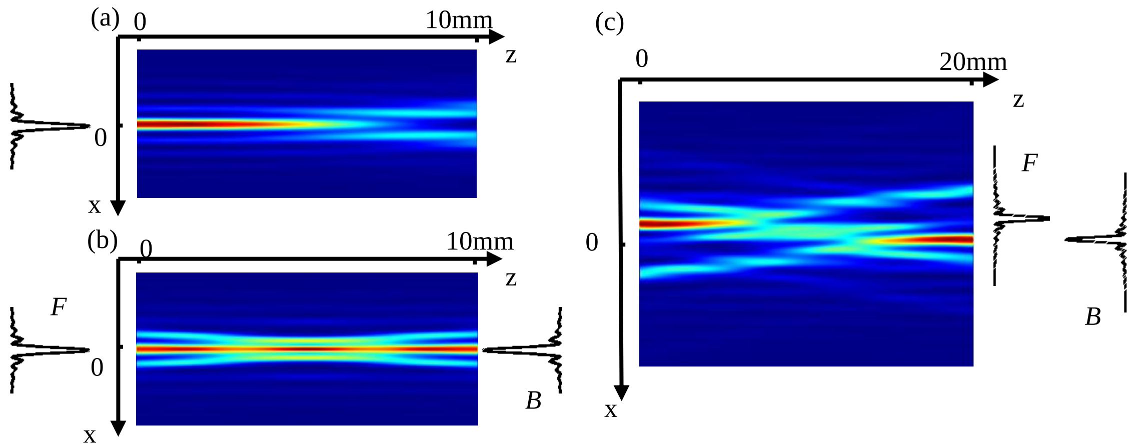

Fig. 1 (a) Intensity distribution of a single gaussian truncated Bessel beam along a 10 mm long photorefractive medium for Γ=3. (b) Intensity of two aligned CP Bessel beams with Γ=4. (c) Intensity of two misaligned CP Bessel beams with Γ=5 in a 20mm long photorefractive medium.

The propagation of the 1D Bessel beams can be described by the numerical model in [1] $i\partial_z F + \partial_x^2 F = \Gamma E_0 F$, $i\partial_z B + \partial_x^2 B = \Gamma E_0 B$, where: F and B are respectively the forward and the backward beams, Γ is the PR nonlinear coupling strength and E_0 is the homogenous part of x-components of the PR space charged field.

As shown in Fig.1 (a), with one propagating Bessel beam and by varying the PR coupling strength, it is possible to form a waveguiding structure with potentially several inputs and 2 outputs. With two aligned CP Bessel beams [Fig.1(b)], multiple inputs/outputs waveguides can be observed because of the self-focusing process arising in the PR medium. In addition, if two misaligned CP Bessel beams are injected [Fig.1(c)], their lobes merge and reorganize themselves in the medium and induce a more complex multi-channels structure with a large possible shift between the different inputs/outputs.

In conclusion, compared to classical optical waveguides obtained with Gaussian beams and multiple waveguides observed with Airy beams, more complex structures with larger transverse shifts and multiple inputs-outputs can be induced in the PR medium using Bessel beams. These results pave the way towards all-optical interconnects, a useful paradigm for new optical communication and information processing.

References

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