1D beam self-trapping in a SBN crystal

K. Pismennaya, O. Kashin, V. Matusevich, A. Kiessling, R. Kowarschik

Friedrich-Schiller-University Jena, Institute of Applied Optics
Max-Wien-Platz 1, D-07743 Jena, Tel. 03641 947659, Fax 03641 947652

mailto: Vladislav.Matusevich@uni-jena.de

In this work we present experimental and numerical investigations of the self-trapping effect in a SBN for gaussian beam for different intensities, and applied electric fields. The temporal development of self-trapping was taken into account. Also the self-bending effect was shown experimentally and calculated numerically.

1 Introduction

Self-trapping in photorefractive materials is one of the most investigated effects during the past decade. Usually one utilizes the Pockel's effect in photorefractive crystals, whereas the natural divergence of the beam is compensated by non-linear focusing. The effect depends on beam intensity and polarization, applied electric field, background illumination, crystal geometry and material properties [1,2].

Photorefractive strontium barium niobate (SBN) crystals are widely used materials for the investigation of photorefractive beam self-trapping and photorefractive solitons [3].

2 Experimental setup

We use a standard schema [4] to produce and observe solitons in a long SBN:60 crystal (5 x 5 x 20 mm^3). A He-Ne laser is used as a source of the monochromatic wave (633 nm).

The intensity of the input beam, which is the maximum of the intensity distribution within the cross-section, is varied from 100 mW/cm^2 up to 270 mW/cm^2. Before focusing the beam it is transformed into a Gaussian beam by a system of lenses and a pinhole so that the maximum of the intensity distribution can be derived from the initial beam power. The applied voltage is taken from 1 kV/cm up to 6 kV/cm, the background illumination amounts to 1.1 mW/cm^2, the input beam diameter takes values between 12 µm up to 40 µm (FWHM)

3 Experimental results

We measure the output beam size parallel and perpendicular to the applied electric field and in dependence on the saturation time and the beam displacement (self-bending).

The beam output profile is in general anisotropic and has an elliptic form with the short axis along the applied field (fig. 1). For values of the applied electric field lower than 1.5 kV/cm the effects are weak. For values higher than 5.0 kV/cm the probability of breakdown increases. We did not notice any essential difference of the output beam size in dependence on the input beam intensity and on the input beam diameters. The output beam profile versus applied electric field remains the same so that the output beam size decreases exponentially and reaches a stable form at about 3 - 4 kV/cm, where the length of the small axis lies between 15 µm and 20 µm and the length of the large axis lies between 20 µm and 25 µm. Out of these observations we can indirectly suppose that independently of the input diameter the beam is focused within the crystal always to the same optimal width.

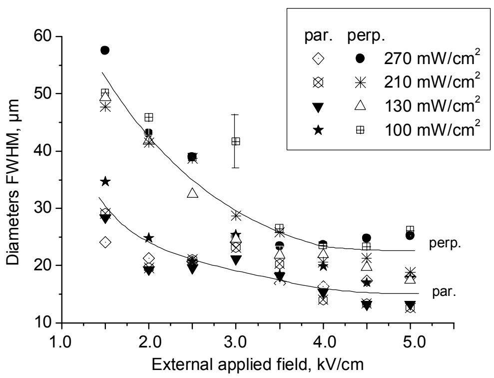

***Fig. 1** Experimental values and average fit of the output beam size parallel (par.) and perpendicular (perp.) to the applied electric field for beam intensities 100 mW/cm^2, 130 mW/cm^2, 210 mW/cm^2 and 270 mW/cm^2 and an input diameter FWHM = 25 µm.*

Fig. 2 shows that with increasing of the applied electric field the beam, as a rule, deviates stronger from the initial direction. But it should be taken into account that there are two different simultaneous temporal processes in the experiment - beam focusing and beam self-bending. Their competition determines a nonlinear behaviour of the dependence at the high voltages.

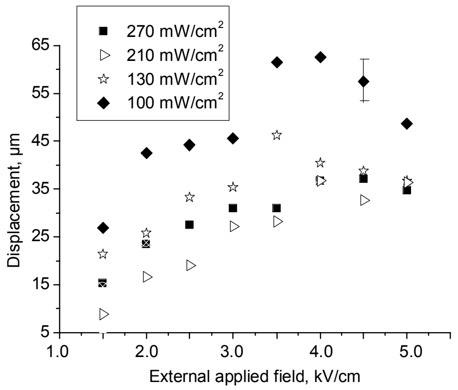

Fig. 2 *Beam displacement as a function of external applied field.for beam intensities 100 mW/cm^2, 130 mW/cm^2 , 210 mW/cm^2 and 270 mW/cm^2 and an input diameter FWHM = 25 µm.*

4 Theoretical results

Our aim is to show theoretically that a Gaussian beam can propagate in a photorefractive crystal in a soliton regime. We use the standard well-known beam propagation method (BPM) [5] to integrate numerically the beam propagation equation to simulate processes in a medium with small refractive index variations.

In our case a modified finite-difference beam-propagation method based on the Douglas scheme [6] was used that leads to a calculation with an accuracy $o(\Delta x)^4$, which is higher than the conventional approach.

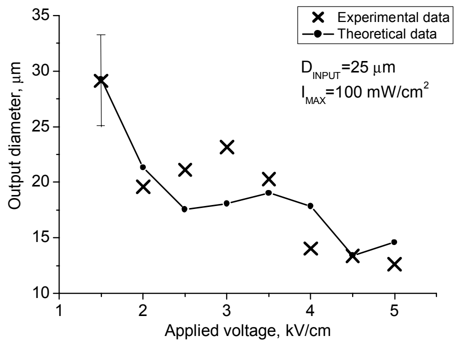

Fig. 3 *Theoretical and experimental output beam diameters for an input peak intensity 100 mW/cm^2 and input diameter 25 µm.*

On Fig.3 the correspondence between our theoretical simulations and experimental data is shown.

Thus we have shown theoretically as well as experimentally that it is possible to generate photorefractive 1D-solitons in a SBN-crystal by a Gaussian beam.

References

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