Focused beam excitation of optical spatial solitons in nematic liquid crystals

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Nematic liquid crystals are an excellent platform for generation and management of optical spatial solitons (Nematicons) through electromagnetically-induced reorientation of their constituent molecules [1]. Despite the considerable number of studies in the field, important details of soliton excitation in actual nematic liquid crystal samples were not addressed to date; here, we investigate the role of input beam parameters such as initial curvature and waist. We studied a 100 μm thick cell filled with E7 liquid crystal mixture in planar molecular orientation. CW Gaussian beams with λ=1064 nm were focused well inside the cell (z_0=-400 μm), at the entrance (z_0=0), or in front of the cell (z_0=400 μm). The molecular director was aligned at 45° with respect to the wavevector, so that extraordinary-polarized input beams of sufficient intensity could all-optically reorient the medium and yield self-focusing. Typical results are illustrated in Fig.1.a. When the focus was positioned at the entrance, i.e. the input phase-front was planar, we obtained the best self-confinement. When the focus was positioned either inside or outside the cell, self-trapping required higher input power due to the curved phase-fronts of the beam. This is visible from the evolution of the beam width (w) versus propagation distance (z) in Fig.1.b.

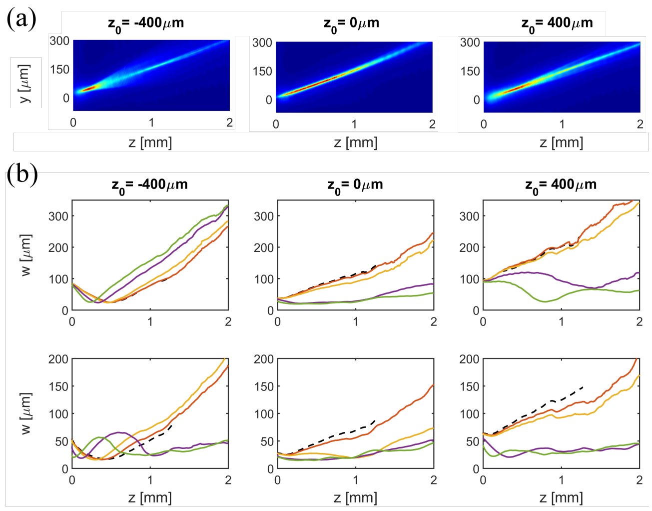

Fig.1. (a) Evolution of a 5 mW extraordinary-polarized beam in the plane yz. (b) w=w(z) curves for w_0=2 μm (top), and w_0=4 μm (bottom). Input powers are 0.4 mW (red), 1 mW (yellow), 5 mW (violet), and 10 mW (green), respectively. The dashed black line plots linear diffraction.

Moreover, for a given focus position, soliton formation required lower powers when the beam waist w_0 was larger, owing to reduced diffraction. It is also worth pointing out that, when the beam was focused inside the sample, the focal point shifted towards the entrance versus power, enhancing the beam divergence due to nonlinear lensing. Our experimental results are in an excellent agreement with theoretical models and numerical simulations; the latter can be easily generalized to other nonlocal nonlinear media.

[1] M. Peccianti and G. Assanto, *Nematicons*, Phys. Rep. **516**, 147 – 208 (2012).