Increasing the spatial soliton propagation distance in nematic liquid crystals

J. Beeckman[a], K. Neyts[a], M. Haelterman[b], H. Azarinia[a]

a Liquid Crystals & Photonics Group, ELIS Department, Ghent University, Sint-Pietersnieuwstraat 41, 9000 Gent, Belgium
b Service d'optique et acoustique, Université libre de Bruxelles CP 194/5, 50 avenue F.D. Roosevelt, 1050 Bruxelles, Belgium

Spatial optical solitons occur when a self-focusing mechanism balances the natural diffraction of the beam. The self-focusing is due to an optical nonlinearity and in nematic liquid crystals this nonlinearity can originate from different mechanisms. In liquid crystals, the mechanism of optical director orientation has been used to generate spatial solitons in most of the cases. This reorientational nonlinearity is maximal when the director makes an angle of 45° with respect to the electric field component of the light. To achieve a high nonlinearity without threshold, one can either use a configuration with [1] or without [2] a bias voltage. Using a bias voltage offers the possibility to tune the magnitude of the nonlinearity. The maximum distance over which a soliton can propagate is always limited due to losses (mainly due to scattering) and fluctuations. The fluctuations can be minimized by stabilizing the liquid crystal orientation by means of a polymer matrix [3] or by applying not only a voltage across the thickness of the cell, but also along the propagation direction [4]. These techniques however cannot take into account the loss of the soliton behaviour over larger distances. Inevitably, due to optical losses, the nonlinearity decreases and the self-focusing becomes too small to compensate for the diffraction effects. In this work, we present a method to compensate for this effect, by increasing the nonlinearity along the propagation direction according to the optical losses. Next to a theoretical analysis of the required increase in nonlinearity, we present numerical and experimental proof of the validity of our method. The use of this technique could offer a major advantage for optical interconnections between optical fibers because larger distances can be overcome with smaller insertion losses due to beam broadening.

References

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