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Trade-offs to obtain phase-only modulation with a twisted nematic liquid crystal display

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Summary

Phase-only modulation using liquid crystal displays (LCDs) is very interesting for many applications (optical signal processing, holographic data storage,...), however, in general they offer a limited phase modulation depth. In this paper we show various alternatives in order to enhance the phase modulation depth.

Introduction

Liquid crystal displays (LCDs) have been widely used as amplitude-only or phase-only spatial light modulators (SLMs) in many applications (optical signal processing, holographic data storage, diffractive optics...). The trend in LCD manufacturing has been to produce thinner displays, since they offer a faster response of the liquid crystal material [1], which enables a better image quality in high resolution LCDs. A thinner device is not a constraint to obtain amplitude-only modulation. However it decreases very significantly the phase modulation depth that can be achieved.

Discussion and conclusions

Phase-only spatial light modulators (SLMs) are required in optical signal processing, phase-coded holographic data storage and in diffractive optics applications. In principle, LCDs provide a coupled phase and amplitude modulation as a function of the applied voltage [2]. A series of methods have been proposed to optimize the phase modulation depth while maintaining a constant amplitude modulation. In thinner devices, the compromise between these two criterions can be maximized combining 3 different elements [3,4]: using elliptically polarized light, using short wavelengths (blue-violet), and using the Jones matrix of the LCD describing its modulation properties as a function of the applied voltage. The Jones matrix is used to perform a computer search to obtain the optimum configuration of the external polarization elements (linear polarizers and wave plates) based on some figure of merit. In general, for phase-only configurations we demand phase-modulation depth close to 360° and a constant and high amplitude transmission. We can find in the literature [5-7] different proposals to characterize the Jones matrix for the LCD.

In this work, we show that alternative phase-only modulation configurations can be obtained depending on the trade-off imposed between the different criterions in the figure of merit. In particular, when the wavelength that we intend to use is a long one

(red-green) we have found that it is necessary to loosen the constraint on the intensity throughput. Although this degree of freedom is normally not used in the literature, we have found that the phase-only modulation obtained is greatly enhanced and may justify, in many applications, the lost of energetic efficiency in the optical setup. Experimental and theoretical results are provided, showing an excellent agreement.

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