ICO-23

-enlightening-the-future-

Santiago de Compostela, 26 – 29 August 2014

Contents

ISBN: 978-84-697-1027-2

International Commission for Optics
Comission Internationale d'Optique

I C O - 2 3

- e n l i g h t e n i n g - t h e - f u t u r e -

Santiago de Compostela, 26 – 29 August 2014

PDF file

(Poster presentation)

Robustness of average Stokes polarimetry characterization of digitally addressed parallel-aligned LCoS displays

Francisco J. Martínez[1,2], Andrés Márquez[1,2*], Sergi Gallego[1,2], Manuel Ortuño[1,2], Jorge Francés[1,2], Augusto Beléndez[1,2] and Inmaculada Pascual[2,3]

[1] *Dept. de Física, Ing. de Sistemas y Teoría de la Señal, Universidad de Alicante, P.O. Box 99, E-03080, Alicante, Spain*

[2] *I.U. Física Aplicada a las Ciencias y las Tecnologías Universidad de Alicante, P.O. Box 99, E-03080, Alicante, Spain*

[3] *Dept. de Óptica, Farmacología y Anatomía, Universidad de Alicante, P.O. Box 99, E-03080, Alicante, Spain*

*EMAIL: andres.marquez@ua.es

Robustness of average Stokes polarimetry characterization of digitally addressed parallel-aligned LCoS displays

Francisco J. Martínez[1,2], Andrés Márquez[1,2*], Sergi Gallego[1,2], Manuel Ortuño[1,2], Jorge Francés[1,2], Augusto Beléndez[1,2], Inmaculada Pascual[2,3]

[1]*Dept. de Física, Ing. de Sistemas y Teoría de la Señal, Universidad de Alicante, P.O. Box 99, E-03080, Alicante, Spain*
[2]*I.U. Física Aplicada a las Ciencias y las Tecnologías Universidad de Alicante, P.O. Box 99, E-03080, Alicante, Spain*
[3]*Dept. de Óptica, Farmacología y Anatomía, Universidad de Alicante, P.O. Box 99, E-03080, Alicante, Spain*
[*]E-mail: andres.marquez@ua.es

Parallel-aligned liquid crystal on silicon (PA-LCoS) displays have become the most attractive spatial light modulator device for a wide range of applications, due to their superior resolution and light efficiency, added to their phase-only capability. Recently we proposed a novel polarimetric method, based on Stokes polarimetry, enabling the characterization of their linear retardance and the magnitude of their associated phase fluctuations, if existent, as it happens in most of digital backplane PA-LCoS devices. In this work we describe the characterization technique together with its predictive capability, and we show some experimental analysis we have performed to delimitate its robustness dealing with the repeatibility and reproducibility of the technique. The calibrated retardance and phase fluctuation values can then be used to estimate the performance of the PA-LCoS device in applications, such as in diffractive optics.

Keywords: Liquid crystal on silicon displays, parallel aligned, retardance measurement, phase-only modulation, spatial light modulation, flicker, diffractive optics, Stokes polarimetry, repeatability and reproducibility.

1. Introduction

The linear variable retarder is a common electrooptical device which may be used to generate or to detect specific states of polarization (SOP) in systems such as Stokes or Mueller matrix polarimeters [1-3] More complex devices, such as parallel aligned liquid cystal on silicon (PA-LCoS) displays, can be assimilated to linear variable retarders [4,5].

It is known that this kind of devices exhibit some flicker or fluctuations in their retardance values. This retardance flicker is produced by the pulsed digital signal addressed. Our group has developed a method to characterize the device based on what we have called averaged Stokes polarimetry [6]. This technique in combination with a Mueller matrix based model allows us to predict the response of the device for every gray level and any kind of SOP at the system entry.

This technique approximates the retardance fluctuations with a triangular time profile. This corresponds to a linear model, thus in general the first option to try. This assumption in combination with a proper selection of the incident SOP enables to extract the retardance fluctuation amplitude from the experimentally measured DoP (Degree of Polarization). From the experimentally measured Stokes parameters S2 and S3 we can calculate the average retardance value, independently of the fluctuation. The detailed explanation about the method is in Ref. [6]

In this work we present a study about the robustness of the method. This study is focused on reproducibility and repeatability capabilities of the proposed characterization method.

2. Calibration, prediction and robustness results

The method consists in measuring all stokes parameters and the DoP at the system exit. The laser beam impinges the system with a known state of polarization, linear polarized light oriented at 45º with respect to the neutral lines of the PA-LCoS. From the data obtained we calculate the average retardance and the fluctuation amplitude for every gray level.

In Fig. 1(a) the measurements are presented. The data can be used to fully characterize the device [6], obtaining the results in Fig. 1(b), where the plot shows the linear dependence of the average retardance with gray level, and the increase with gray level of the fluctuation amplitude.

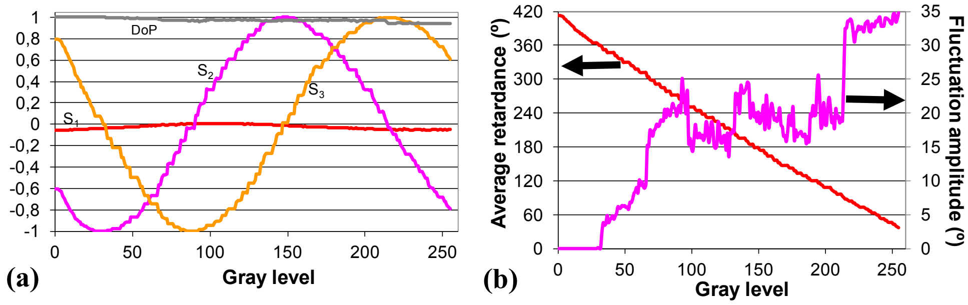

Figure 1 (a) Experimental values for the Stokes parameters and DoP, for input SOP linear at +45º; (b) Calculated values for the average retardance and the fluctuation amplitude. Results obtained for λ=633nm.

As we demonstrated in Ref. [6] these characterization data can be used to predict the exit SOP for an arbitrary SOP incident onto the PA-LCoS. The polarimetric data has been obtained with a rotating waveplate-based polarimeter, model PAX5710VIS-T distributed by the company THORLABS. The LCoS used in this work is provided by the company HOLOEYE, model PLUTO-VIS. We use the electrical configuration named as "5-5 2pi linear 633nm", that it is optimized for 633nm laser wavelength, and it is capable to generate 360º of retardance dynamic range.

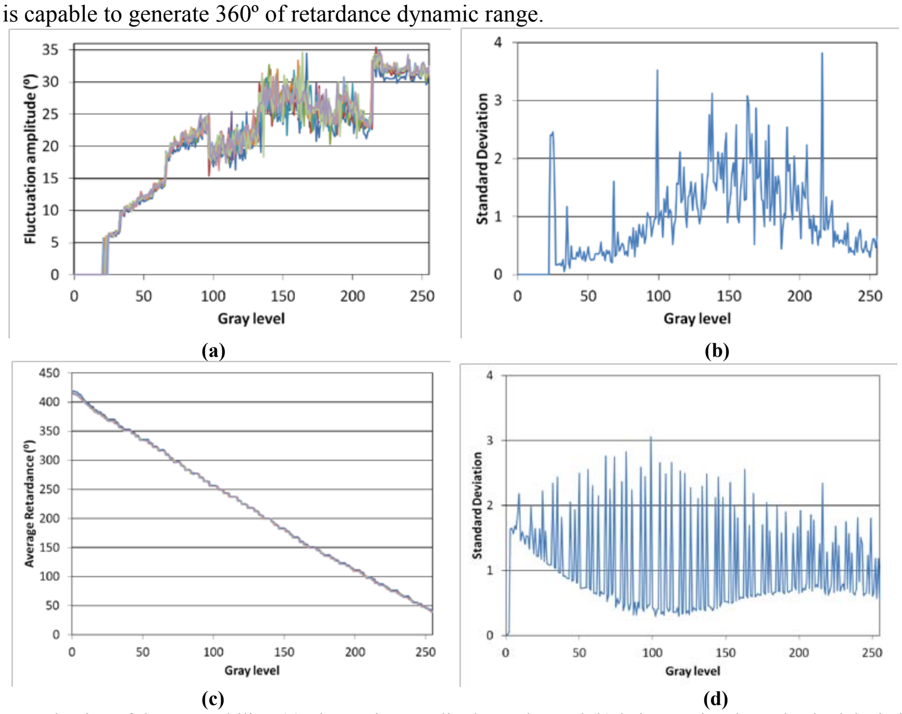

Figure 2 Evaluation of the repeatability. (a) Fluctuation amplitude results, and (b)their associated standandard deviation. (c) Average retardance results, and (d) their associated standard deviation.

To evaluate the repeatability of the measurement method we have taken a total of 10 successive measurements under the same conditions: this means that first we aligned all instruments and without changing conditions we have taken the data several times in a row. We evaluate the associated standard deviation as the figure of merit to estimate the repeatability.

In Fig. 2(a) and (c) we show the fluctuation amplitude and the average retardance calculated from the ten different measurements taken in a short time interval. We see that the measurements for the various series are very similar, with standard deviations (Fig. 2(b) and (d)) around 1-2º both for the fluctuations amplitude and for the average retardance measurements.

Next we have analyzed the reproducibility of the method by comparing 3 different series of measurements acquired in different years. The experimental set-up has been rebuilt from scratch in each case, so as to evaluate the deviations that can be introduced by the alignment tolerances produced by the human operator.

In Fig. 3(a) and (b) we see the measurements obtained. We remark that we have no temperature room control, which may affect the liquid crystal properties, so the small difference that we observe may be partly due to different temperature, together with the inherent uncertainty that we introduce in the orientation of the polarizer or in the alignment of the other various elements.

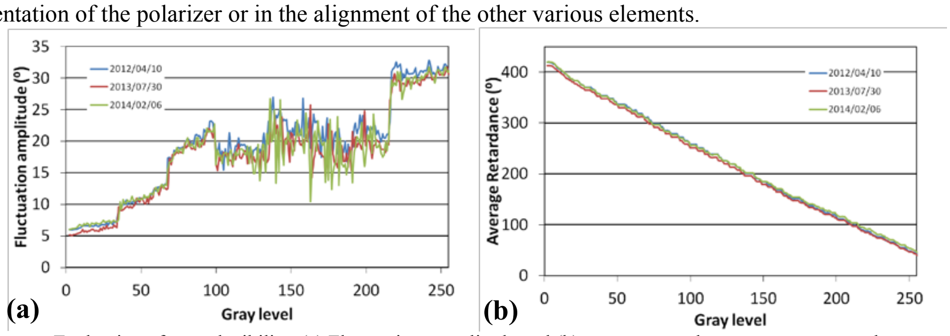

Figure 3 Evaluation of reproducibility. (a) Fluctuations amplitude and (b) average retardance measurements changes over large periods of time.

3. Conclusions

We can conclude that our method is robust. We have showed that the results show a high degree of repeatability and reproducibility. The time interval between measurements and uncertainties in the alignment of all elements in the set-up do not produce significant deviations.

Acknowledgments

Work supported by Min. de Trabajo y Competitividad of Spain (projects FIS2011-29803-C02-01 and FIS2011-29803-C02-02), by Gen. Valenciana of Spain (projects PROMETEO/2011/021 and ISIC/2012/013), and by Universidad de Alicante (project GRE12-14).

References

[1] G. Goldstein, *Polarized Light*, (Marcel Dekker, New York 2003).

[2] A. De Martino, Y. K. Kim, E. Garcia-Caurel, B. Laude, and B. Drévillon, "Optimized Mueller polarimeter with liquid crystals," Opt. Lett. 28, 616–618 (2003).

[3] A. Peinado, A. Lizana, J. Vidal, C. Iemmi and J. Campos, "Optimization and performance criteria of a Stokes polarimeter based on two variable retarders," Opt. Express 18, 9815-9830 (2010).

[4] S. T. Wu and D. K. Yang, *Reflective Liquid Crystal Displays*, (John Wiley & Sons Inc., Chichester, 2005).

[5] N. Collings, T. Davey, J. Christmas, D. Chu, and B. Crossland, "The Applications and Technology of Phase-Only Liquid Crystal on Silicon Devices", J. Display Technol. 7, 112-119 (2011).

[6] F.J. Martínez, A. Márquez, S. Gallego, J. Francés, I. Pascual and A. Beléndez, "Retardance and vlicker modeling and characterization of electro-optic linear retarders by averaged Stokes polarimetry," Opt. Lett. 34, 1011-1014 (2014).