Assignment for LabVIEW course

2021-02-06

[Content]

[Main Text]

1. Aim of the Assignment

The assignment this time is to draw a calibration curve of a liquid crystal variable retarder (LCVR). The curve shows the relations of the phase retardance and applied voltages to the LCVR.

2. Method of LCVR Calibration

2.1 Background Introduction

An LCVR is a nematic electro-optical modulator in polarization optics. It achieves phase retardance variation by applying a corresponding voltage. An accurate retardance-voltage relationship is needed to operate an LCVR properly.

2.2 Calibration Method

The testing LCVR is sandwiched between two perpendicular or parallel linear polarizers (Wu et al. 1984), and the fast axis of the LCVRis 45°, with respect to either axis of the polarizer, as shown in Figure 1. In the example case, the orthogonal light intensities from both perpendicular and parallel polarizers are recorded in the same image, as Figure 2 shows. The intensities of the light intensities in the two beams of perpendicular polarization are expressed as

$$\begin{cases} L_{\perp} = I_0 \exp(-\alpha_0 d) \sin^2 \dfrac{\delta}{2}, \\ L_{\parallel} = I_0 \exp(-\alpha_0 d) \cos^2 \dfrac{\delta}{2}, \end{cases} \#(1)$$

where$I_0$is the light intensity incident into the system, $\alpha_0$represents the liquid crystal absorption coefficient for the ordinary ray, and $d$is the thickness of the liquid crystal.

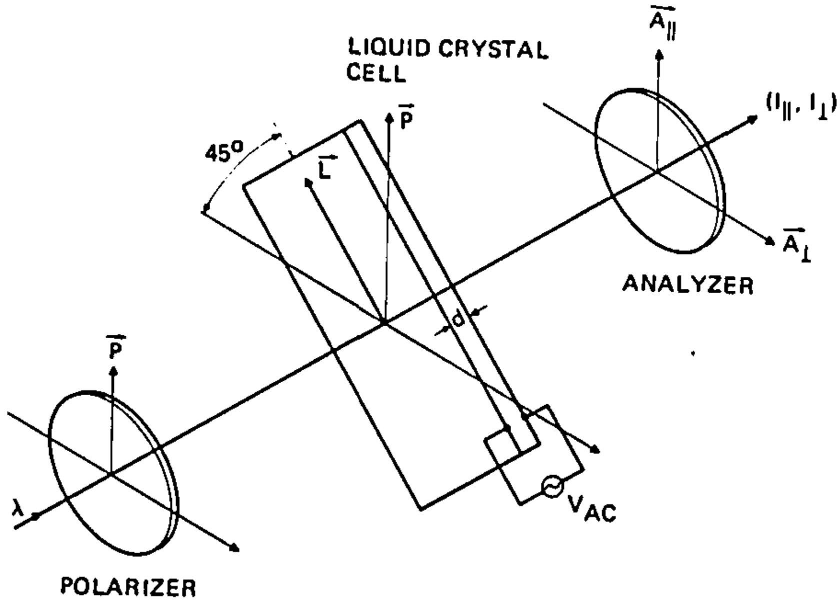

Figure 1. Schematic diagram of experimental apparatus and optical configuration for liquid crystal birefringence measurements.

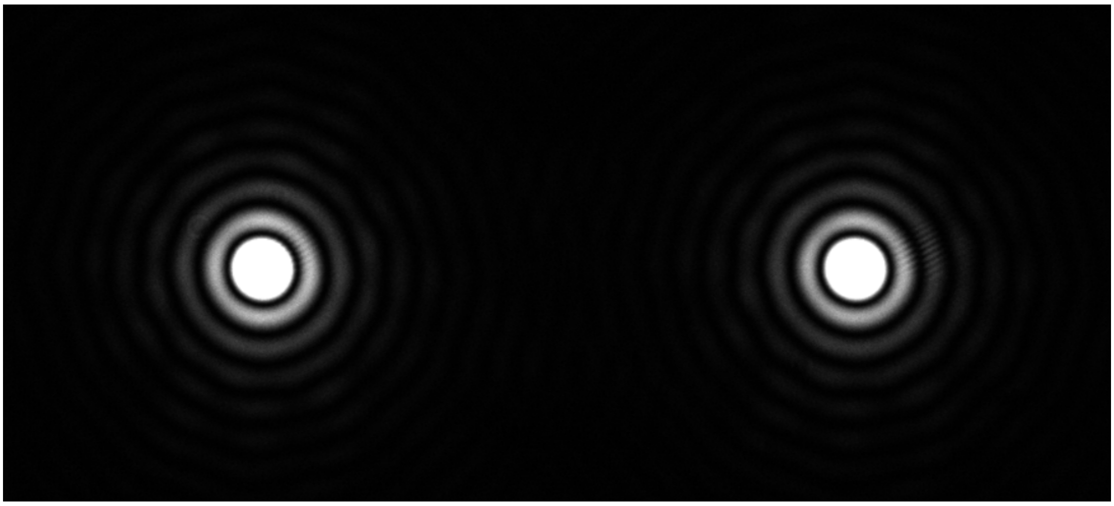

Figure 2. Example of orthogonal light intensities in the LCVR calibration.

From equation (1), we can work out the LCVR retardance by dividing the $L_\perp$ and $L_\parallel$, which yields

$$\delta = \begin{cases} N\pi + 2\tan^{-1}\sqrt{\dfrac{L_\perp}{L_\parallel}} & N = 0, 2, 4, \ldots \\ (N+1)\pi - 2\tan^{-1}\sqrt{\dfrac{L_\perp}{L_\parallel}} & N = 1, 3, 5, \ldots \end{cases}, \#(2)$$

where $N\pi$ is the ambiguity for the determination of δ. For 0°≤δ≤180°, we use equation (2a) with N=0 to calculate the δ. For 180°≤δ≤360°, we use equation (2b) with N=1 to calculate the δ. An example of the LCVR retardance-voltage relationship is shown in Figure 3.

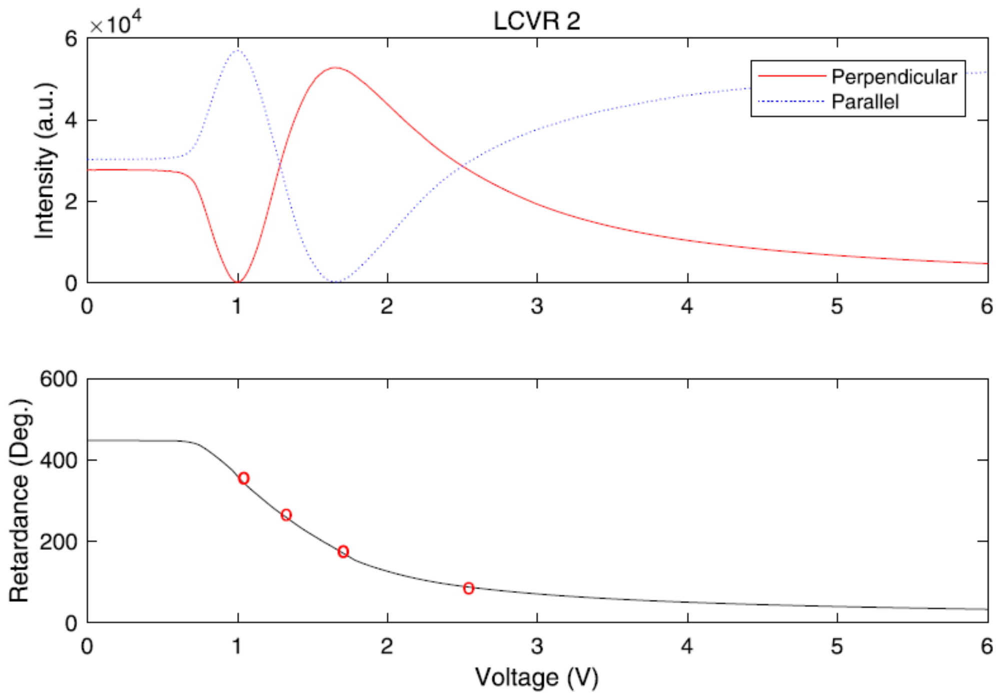

Figure 3. Retardance-voltage relationship of a testing LCVR.

3. Requirements of the Assignment

A series of LCVR calibration intensity images is given. The range of the applied voltages is from 0V to 6V, with an interval of 0.3V. Using these 21 intensity images to draw a calibration curve as Figure 3 shows, using Equation (2).

According to equation (2), you need to measure the intensities in the 2 beams. Here we use a point source, and you will see 2 bright spots in the 2 beams (i.e. left side and right side spot respectively, in the same image). By measure the maximum intensity in the 2 beams in each image, they will be used as the $L_{\perp}$ and $L_{\parallel}$ in the equation (2), an calculate the phase retardance at each image that corresponding to specific voltage, and thus make the retardance-voltage plot, shown in Figure 3 by measuring all images. This is the requirement for this assignment.

21raw images are provided, each image corresponds to a specific voltage and can be used to calculate phase as one point in the retardance-voltage plot. So, you will have 21 points to construct the plot.

Two LabVIEW example codes are provided, and you can use them as the start-point for your assignment.

[References]

Ren, D., Han, Z., and Guo, J.: 2020, A high-efficiency and high-accuracy polarimeter for solar magnetic field measurements. *Solar Physics* 205, 109.

Wu, S.-T., Efron, U., Hess, L.D.: 1984, Birefringence measurements of liquid crystals. *Appl. Opt.* 23(21), 3911.