20th Conference of Czech and Slovak Physicists, 7 – 10 September 2020, Prague, Czech Republic

# PHASE BIREFRINGENCE DISPERSION FUNCTION AS A COMPLEMENTARY TOOL FOR INVESTIGATION OF NEMATIC LC STRUCTURE

Norbert Tarjányi, Marek Veveričík and Daniel Káčik,
Department of Physics, Faculty of Electrical Engineering and Information Technology, University of Žilina,
Univerzitná 8215/1, 010 26 Žilina, Slovakia
E-mail: norbert.tarjanyi@feit.uniza.sk, vevericik@fyzika.uniza.sk, daniel.kacik@feit.uniza.sk

## Introduction

One of the natural properties of a liquid crystal is its birefringence. Often, the feature is used for the construction of polarizing elements, light intensity or phase modulators, and sensors but also it has the potential to be used as an additional tool for the study of electronic absorption bands of LC in the UV and near-UV region. Such an approach is suggested in the contribution.

## Sample preparation and experiment

The material we studied was a thin film of nematic liquid crystal, 6CHBT. The investigation was performed at the temperature of 24.5 °C. The sample thickness was (50 ± 0.1) μm. Light from the halogen lamp impinged the first polarizer, propagated through the LC sample and was collected by an optical fiber with a core diameter 400 μm and a numerical aperture 0.39 placed behind the second polarizer (Fig. 1).

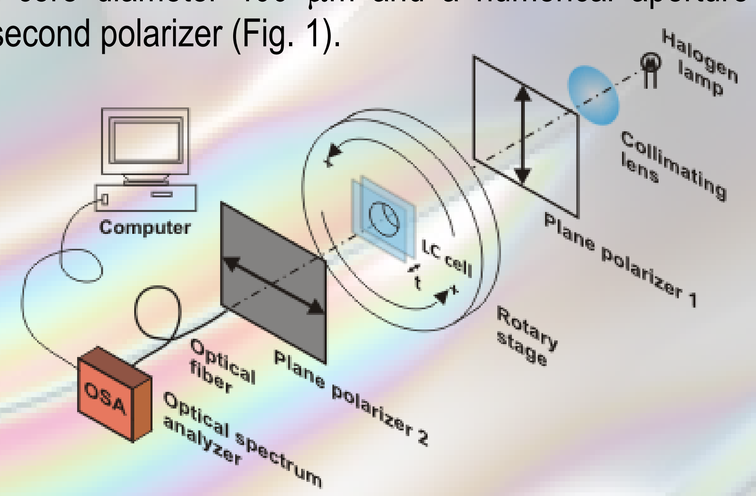


Fig. 1 Set-up used for investigation of 6CHBT liquid crystal phase birefringence.

It stems from the theory that in case of a uniaxially birefringent sample, which is placed between two crossed plane polarizers, the intensity of light behind the second polarizer is expressed by Eq. (1)

$$I(\lambda) = I_0(\lambda)\cdot\left\{\sin\left[\frac{\pi t}{\lambda}\Delta n(\lambda)\right]\right\}^2$$

By rotating the stage with the sample we found its proper position for which a well detectable characteristic channeled spectrum emerged at the OSA (Fig. 2).

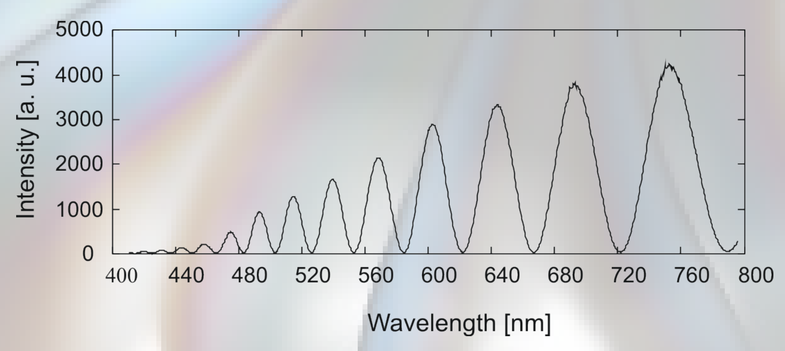


Fig. 2 The measured channeled spectrum.

## Phase birefringence

The dispersion of phase birefringence $\Delta n(\lambda)$ can be determined from the measured channeled spectrum using Eq. (1) and an appropriate model describing the birefringence of the liquid crystal, e.g. one expressed by Eq. (2)

$$\Delta n(\lambda, T) \approx \sum_j G_j(T)\frac{\lambda^2\lambda_j^2}{\lambda^2-\lambda_j^2}$$

## Results and discussion

The phase birefringence dispersion (particularly, the parameters $\lambda_j$ and $G_j(T)$) was found by fitting the measured channeled spectrum with the function described by Eq. (1) in which the phase birefringence $\Delta n(\lambda)$ had the form expressed by Eq. (2). Table 1 shows the particular values of the parameters obtained by the fitting in cases of the considered 1- and 2-bands models. The best fit is shown in Fig. 3.

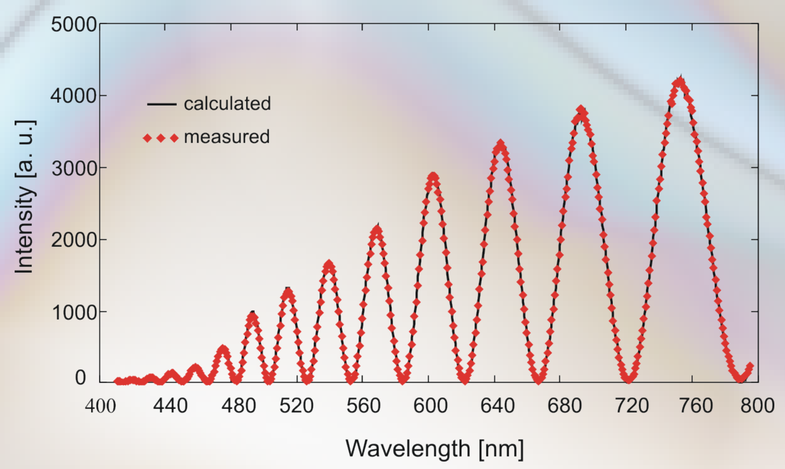


Fig. 3 The measured channeled spectrum fitted by the calculated one using Eq. (1) and Eq. (2).

TAB. 1. Values of the obtained fitting parameters.

| | 1-band model | 2-bands model |
|---|---|---|
| $\lambda_1$ [nm] | 219.31 | 107.34 |
| $G_1$ [nm$^{-2}$] | $2.72\cdot10^{-6}$ | $5.12\cdot10^{-6}$ |
| $\lambda_2$ [nm] | - | 256.67 |
| $G_2$ [nm$^{-2}$] | - | $1.11\cdot10^{-6}$ |

Figure 4 shows the phase birefringence dispersions calculated according to Eq. (2) using the parameters listed in TAB.1. The deviation between them is illustrated by their ratio plotted in Fig. 5. For clarity, there is also plotted a curve representing the unity which expresses the case when the two dispersion curves would be the same. Thus, it can be seen that the deviation between dispersion curves calculated according to 1- and 2-bands models is a maximum of 1%. Nevertheless, the deviation between the measured and the calculated channeled spectrum, which is less than 2.5% in our case, is decisive.

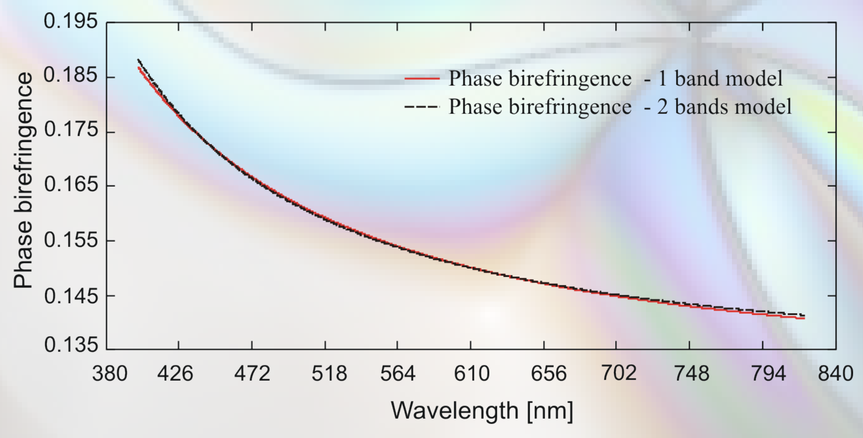


Fig. 4 Phase birefringence calculated according to Eq. (2).

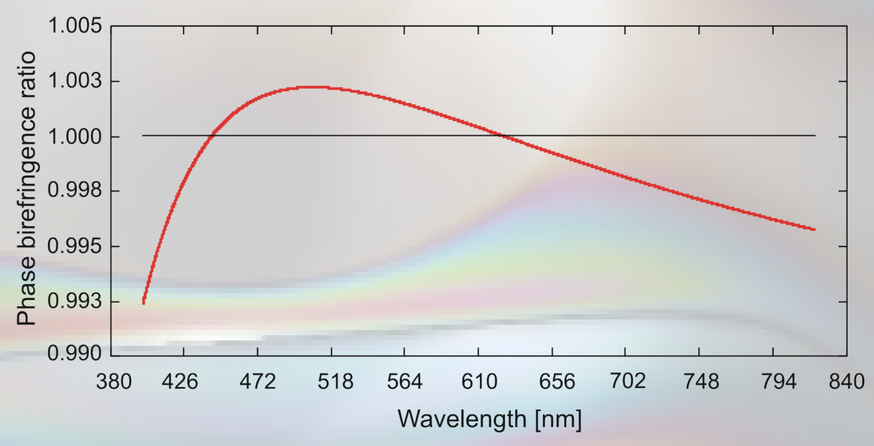


Fig. 5 The ratio between phase birefringence dispersions calculated according to 1- and 2-bands models.

## Conclusions

We investigated the phase birefringence dispersion of pure 6CHBT liquid crystal in the visible spectral range and at the temperature of 24.5 °C. The phase birefringence dispersion $\Delta n(\lambda)$ was determined by fitting the calculated channeled spectrum to the measured one. The deviations between the measured and the calculated spectra were about 10% in the case of a 1-band model and less than 2.5% in the case of 2- bands model and stayed unchanged also in case of a 3-bands model. Such a good match promises to use the approach as a complementary investigation method of LC optical properties to the existing absorption or ellipsometric measurements, the aim of which is to characterize the optical properties of a liquid crystal sample.

ACKNOWLEDGMENT: This work was supported by the Slovak Research and Development Agency under the Contracts no. APVV-15-0441 and APVV-19-0602, and projects VEGA 2/0016/17 and VEGA 1/0069/19.