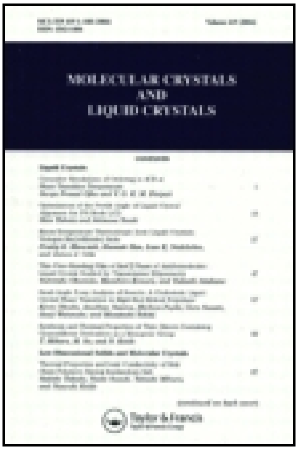

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R. Bartolino [a b] , C. Umeton [a b] , F. Ye [a b] & F. Simoni [a b]

[a] Unical Liquid Crystals and Optics Group GNSM-CISM Unita di Cosen za

[b] Dipartimento di Fisica, Universita della Calabria, 87036, Rende, CS, ITALY
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OPTICAL MODULATION INDUCED BY STRESSED CHOLESTERIC LIQUID CRYSTALS

R. BARTOLINO, C. UMETON, F. YE and F. SIMONI
Unical Liquid Crystals and Optics Group
GNSM - CISM Unità di Cosenza
Dipartimento di Fisica - Università della Calabria
87036 Rende (CS) ITALY

Abstract Experimental results on the rotatory power of a stressed Cholesteric Liquid Crystal are reported. The dependence on the applied strain is measured and a critical dependence on the light wavelength is shown. Applications of this effect to optical modulation is also reported.

In previous researches we have studied the optical properties of a Cholesteric Liquid Crystal (C.L.C.) subjected to normal mechanical strains. For small deformations we have demonstrated the existence of a steady state elastic behavior[1]. In this paper we show a strong variation of the optical rotation induced by the C.L.C. and report applications of this effect to optical modulation.

The electromagnetic theory of wave propagation along the axis of a C.L.C. can be easily extended to include the effects of small deformations just defining the molecular twist angle as[2]

$$(z) = 2\pi(z - u)/p_o$$

where u = u(z) is the displacement of the molecular layer. Here we consider only the elastic regime where $u = \alpha z$, with

$\alpha = \delta/(\delta + d)$; d is the unperturbed C.L.C. thickness and δ is its variation ($\delta > 0$ for dilation and $\delta < 0$ for compression). Following this method, the well known expression for the rotatory power of a C.L.C. is reobtained:

$$R = \frac{-2\pi}{p}\left(\frac{(\delta\varepsilon)^2}{8\lambda'^2_p\,(1-\lambda'^2_p)}\right)$$

with these new definitions:

$p = p_o/(1-\alpha)$, $\lambda'_p = \lambda'(1 - \;)$.

All the other variables have the usual meaning.

Using the technique of the spinning analyzer[3], we have measured the optical rotation induced by the C.L.C. under different strain conditions and for different wavelengths. Experimental measurements of R versus the light wavelength are reported in fig. 1 for different strain conditions. In the same figure full lines correspond to theoretical calculations and show a good agreement with experimental data.

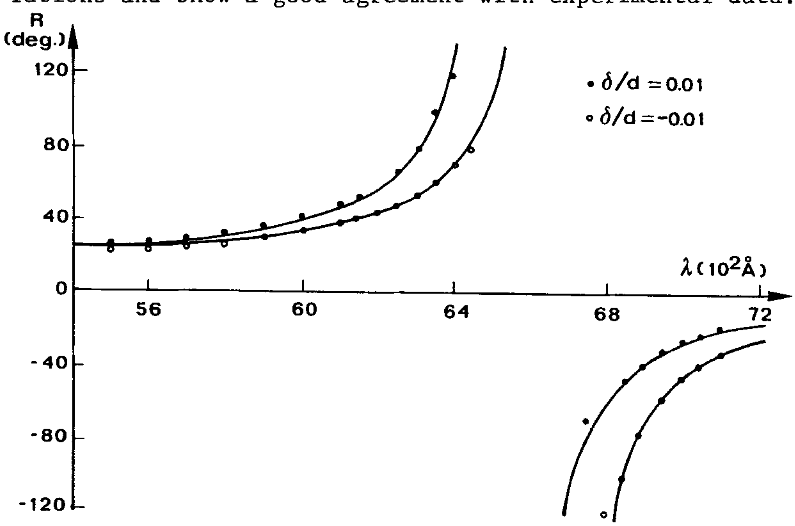

FIGURE 1. Optical rotation R vs light wavelength.

An important feature evident from these data is the strong variation of R at a fixed wavelength for different strain conditions. This is better explained in fig. 2 where the variation $R - R_o$ of the optical rotation is reported vs δ/d. Of course this effect is lower for wavelengths far from the reflection peak. The used sample is a mixture of ChCl, ChO and ChN with the reflection maximum at λ_o = 6600 Å.

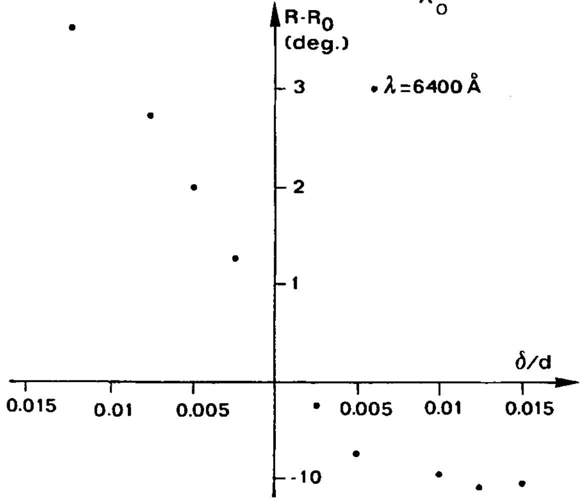

FIGURE 2. Variation of the optical rotation vs the applied strain.

The effects described before are the basis of the working operation of the Stress Controlled Polarizer (S.C.P.) which an international patent is pending for.[4] The C.L.C. sample, placed in between two polarizers, acts as intensity modulator when a mechanical periodic deformation is applied. The deformation is obtained by a piezoelectric driver connected to one wall of the sample.

We have studied the dependence of the modulation on the light wavelength, the sample thickness and the applied deformation. As usually, we define the optical modulation as

$M = (I_{max} - I_{min})/I_{max}$

where I_{max} and I_{min} are respectively the maximum and minimum value of the transmitted intensity.

In fig. 3 M is reported vs the exciting frequency for a sample 9 μm thick. A cut-off frequency of about 10 Hz is evident.

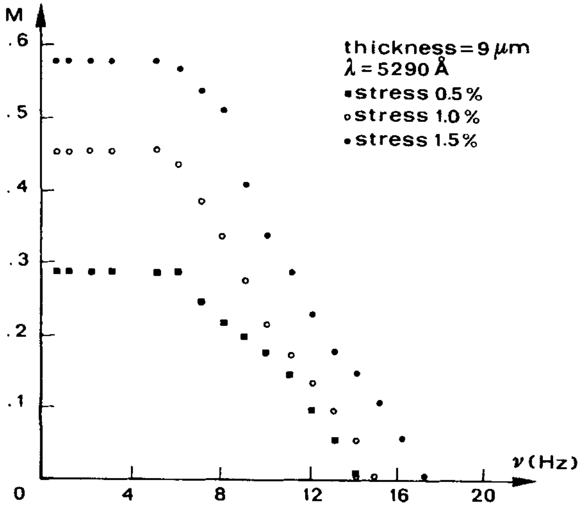

FIGURE 3. Optical modulation M vs the exciting frequency.

In fig. 4 the dependence of M on the sample thickness is shown for a fixed stress value and two modulation frequencies.

The main features, interesting for applications, of the presented S.C.P. are the linear behavior in the elastic regime, the control of the sign of variations of the optical rotation and a wide range of variation which can be exploited passing from dilation to compression.

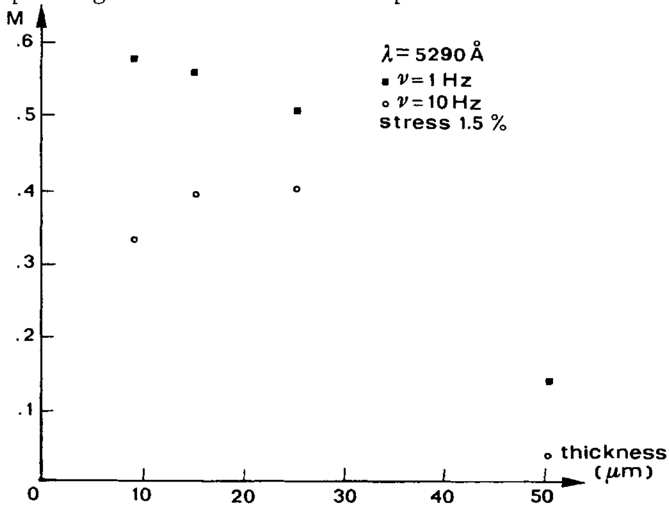

FIGURE 4. Optical modulation M vs the sample thickness.

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