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TP32 Time-Dependent Dynamical Reorientation Induced by CW Laser Beam In a Nematic Liquid Crystal Film

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Liquid crystals in their mesophases are attractive materials for nonlinear optical devices because of their huge response to optical fields and their capability of being easily inserted in optically integrated structures. From the macroscopic point of view, we may consider a nematic liquid crystal as a fluid endowed with internal orientational degrees of freedom. These additional degrees of freedom, absent in ordinary fluids, may be accounted for by the director field $\mathbf{n}(\mathbf{r})$, a unit vector field attached at each point $\mathbf{r}$ in the medium. Unlike in the case of externally applied static fields, where $\mathbf{n}$ couples with the external field directly, in the case of optical fields $\mathbf{n}$ couples with the light polarization. As a consequence, $\mathbf{n}$ is driven by exchange of angular momentum between the light beam and the medium. This yields the appearance of various new nonlinear optical phenomena having no analogue in the static-field case. For instance, the molecular director $\mathbf{n}$ can be put into uniform precession about the beam propagation direction by transfer of intrinsic angular momentum (photon spin) from the beam to the liquid crystal[1]. This effect can be observed only with circular polarization of the incident beam, for, in this case only, the deposition of angular momentum in the medium has a constant rate. With an elliptically polarized beam, the situation is far more intriguing. The main difference between circular and elliptical input polarization is that in the former case the molecular reorientation first breaks the azimutal symmetry of the whole system (radiation + liquid crystal). This yields characteristic different results in the two cases: the elliptically polarized input can lead the system through various dynamic regimes: torsional oscillations, nonuniform precession, nutation of $\mathbf{n}$ superimposed on precession, and others.

In this work, we present the first experimental quantitative study of the dynamical phenomena occuring when a nematic liquid crystal film is reoriented by an elliptically polarized laser beam at normal incidence. The experiment was carried out on a 75µm homeotropic film of 4-cyano-4'-pentyl-biphenyil (5CB). An Ar^+ laser beam, focussed to 120 µm and normally incident on the film was used as pump beam, and a counter-propagating He-Ne laser beam, mounted in a heterodyne interferometer/polarimeter scheme, was used to probe the induced molecular reorientation. An example of the observed oscillations of the molecular director $\mathbf{n}$ is shown in Fig.1, where the angle ψ of the polarization axis of the probe beam beyond the sample is plotted as a function of time. We observed different laser-induced dynamical regimes,

[1] E.Santamato, B.Daino, M.Romagnoli, M.Settembre, and Y.R.Shen, Phys.Rev. Lett., **57**, 2423 (1986)

depending on the input intensity and/or polarization ellipticity. The results are summarized in Fig.2, where the various distorted "dynamical phases" of the system are indicated in the intensity/ellipticity plane. In the figure U denotes undistorted regime, S steady-state distortion, O torsional oscillation, in which the oriented molecules librate, and R the precession/nutation regime, in which the molecules precess as well as nutate about the beam propagation direction. Squares, circles, and triangles are experimental data points in different regimes. Empty and filled symbols refer to observation with increasing and decreasing pump intensity, respectively. The dashed curve describes the boundary between R and O with decreasing pump intensity. Hysteresis betweeen these two time-dependent regimes is clearly shown. Also, a theoretical model has been developped, consistent with total (radiation + medium) angular momentum conservation, whose results are in good agreement with the experimental observations.

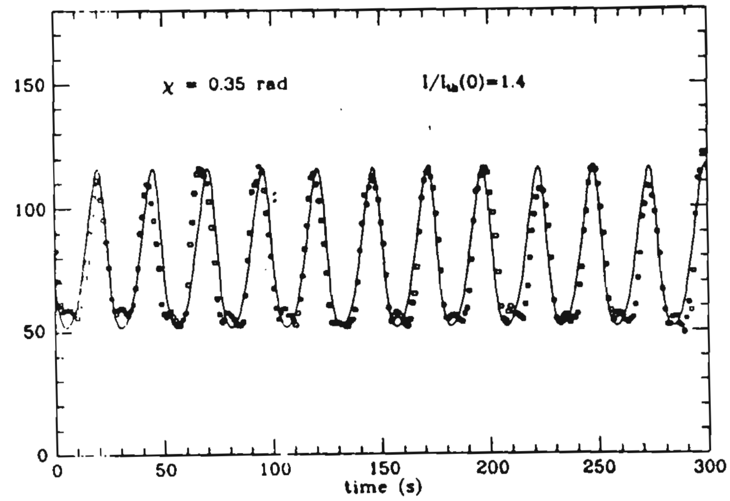

Fig.1 Angle ψ of the polarization ellipses major axis of the probe beam beyond the sample as a function of time. In the figure, the pump intensity and ellipticity angle are indicated by I and χ, respectively. $I_{th}(0)$ denotes the threshold for the Optical Fréedericksz Transition with linear pump polarization.

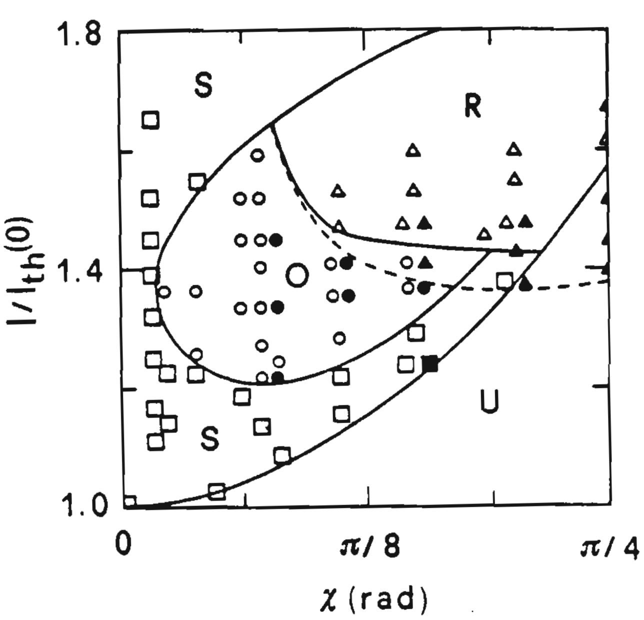

Fig.2 Zone diagram in the (χ,I)-plane for the observed dynamical regimes. $I_{th}(0)$ denotes the threshold for the Optical Fréedericksz Transition with linear pump polarization.