Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl16

Frank Constant Determination in a Nematic Liquid Crystal by Light Attenuation Measurement

E. Miraldi [a b] , C. Oldano [a b] , P. Taverna Valabrega [a b] & L. Trossi [a b]
[a] Istituto di Fisica Sperimentale, Politecnico C.so Duca degli Abruzzi, 24 -10129, Torino, Italia
[b] Gruppo Nazionale Struttura della Materia del C.N.R., U.R. 24
Version of record first published: 20 Apr 2011.

To cite this article: E. Miraldi , C. Oldano , P. Taverna Valabrega & L. Trossi (1982): Frank Constant Determination in a Nematic Liquid Crystal by Light Attenuation Measurement, Molecular Crystals and Liquid Crystals, 82:7, 231-236

To link to this article: http://dx.doi.org/10.1080/01406568208247008

Mol. Cryst. Liq. Cryst. Vol. 82 (Letters), pp. 231-236
0140-6566/82/8207-0231$06.50/0

FRANK CONSTANT DETERMINATION IN A NEMATIC LIQUID CRYSTAL BY LIGHT ATTENUATION MEASUREMENT

E.MIRALDI, C.OLDANO*, P.TAVERNA VALABREGA and L.TROSSI

Istituto di Fisica Sperimentale, Politecnico
C.so Duca degli Abruzzi, 24 - 10129 Torino, Italia
* Gruppo Nazionale Struttura della Materia del C.N.R., U.R. 24
(Submitted for publication July 1, 1982)

Abstract: A simple method for measuring the elastic Frank constants of a nematic liquid crystal is described. The method consists in measuring the attenuation of a laser beam transmitted through the specimen as a function of the angle of incidence and making a best fitting by using the results of a theory developed in a previous paper.
Some experimental results concerning MBBA liquid crystals are reported and discussed.

INTRODUCTION

The light scattering cross-section of nematic liquid crystals depends essentially on its optical anisotropy and on the amplitude of the thermal fluctuations of the optical axis. This amplitude is determined by the three K_{jj}'s Frank elastic constants.

It is therefore possible to evaluate these constants by light scattering cross section measurements. Actually so far have been obtained: a) the ratios K_{ii}/K_{jj} [1,2] and the absolute values of K_{jj} [3] through differential cross section measurements; b) the absolute values of K_{jj} through total cross section measurements [4]. The method a) gives results intrinsically imprecise because the scattered intensity of first order is always low, so that it becomes comparable with the scattering due to surface defects or to multiple scattering. In the method b) the total scattering cross section can be measured with an error which may be limited to a few percent, but this affects the constants K_{jj} with an error which is one or two orders of magnitude larger.

The purpose of the present letter is to show how it is possible to determine the three K_{jj} constants simply by measuring the behaviour of the total scattering cross section as a function of the angle ϑ_i^e between the incident beam and the normal to the sample surface.

Practically one measures the ratio between the transmitted intensity I through the sample for different angles ϑ_i^e and the intensity Io transmitted at normal incidence. This new method, with respect to b), allows both to simplify the K_{jj} measuring technique and to improve the precision of the measure of the constants K_{jj} as well.

Experimental set-up and results

The experimental measurements have been performed on a MBBA sample homeotropically aligned between two glass plates (0.95 mm thick) by recording the intensity I of the transmitted light in the direction of the laser beam for different angles of incidence ϑ_i^e. A 3 mW He - Ne laser was used as a light source. The transmitted light and a fraction of the incident light were sent to two separate photodiodes (Fig. 1). This allowed to compensate for the laser intensity fluctuations by measuring, the ratio of the signals coming from the photodiodes.

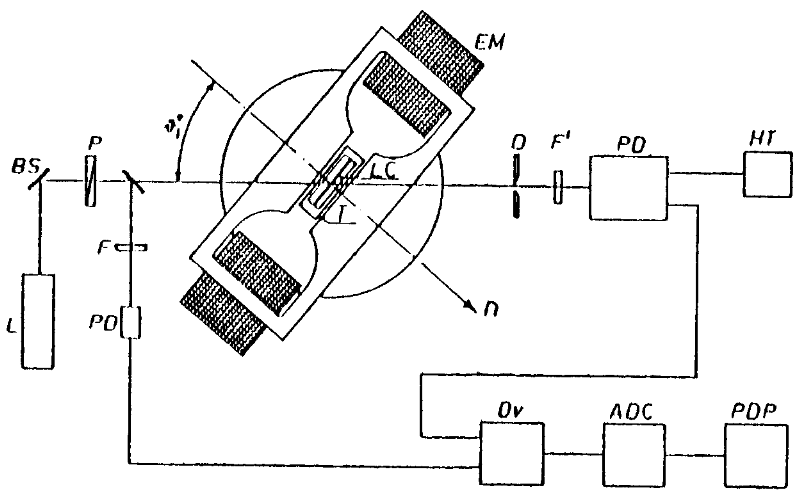


Fig. 1 - L laser; BS beam splitter; P polarizer; F, F' filters; PD photodiode; T thermostat; LC liquid crystal sample; D diaphragm; EM electromagnet; Dv divider; ADC analog to digital converter, PDP processor computer on line.

A magnetic field of about 3000 Gauss was used to reduce the forward scattering of the incident light due to long wavelenght thermal fluctuations. The further screening of the forward scattered light by means of a suitable diagram allowed to contain the ratio between scattered light and transmitted light to only about 1%. The 1st and 2nd order scattering were extimated on the basis of the calculations given in ref. (5).

In Fig. 2 are reported the experimental points I/Io for extraordinary and ordinary polarization respectively. Full lines represent a best fit obtained by varying the K_{jj}'s in the theoretical expression of the intensity[5].

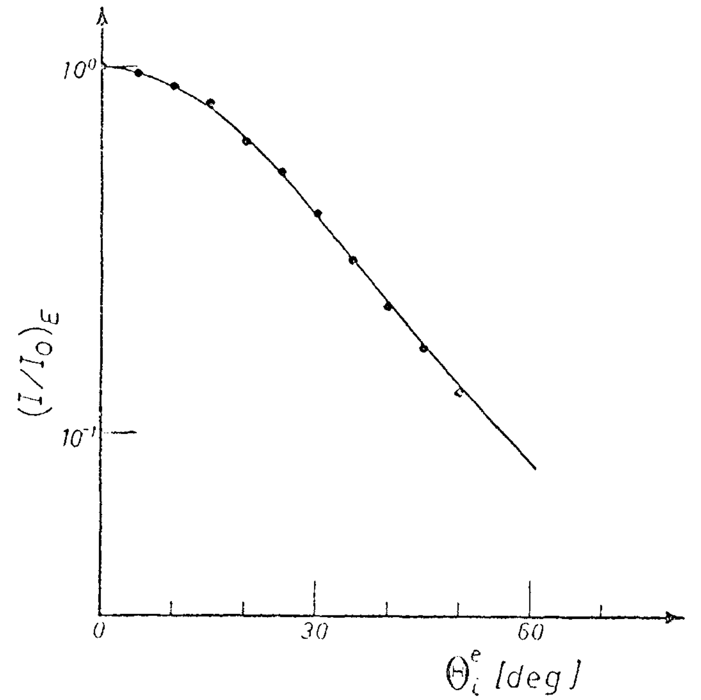
Taking into account that for the used samples the true absorption coefficient is negligibly small, the total scattering cross section is obtained by measuring the attenuation coefficient. This coefficient depends on the three K_{jj} constants which can thus be obtained by performing at least three measurements using different geometries.

The error can be estimated as follows. Let Y_i (K_{11}, K_{22}, K_{33}) with i = 1,2,3, represent the values of the ratios I_i/I_o corresponding to three different light incidence angles. For small variations of K_{jj}'s around their best fit values, the dependence of the Y_i's on K_{jj}'s can be linearized, i.e.:

$$(1) \qquad Y_i = Y_{i,o} + \sum_{i,j=1,2,3} C_{ij} \Delta K_{jj}$$

where $Y_{i,o}$ is the best fit value.

The error of propagation from the directly measured Y_i's to the evaluated K_{jj}'s has been obtained by inverting their functional dependence given by eq.(1) and resulted strongly



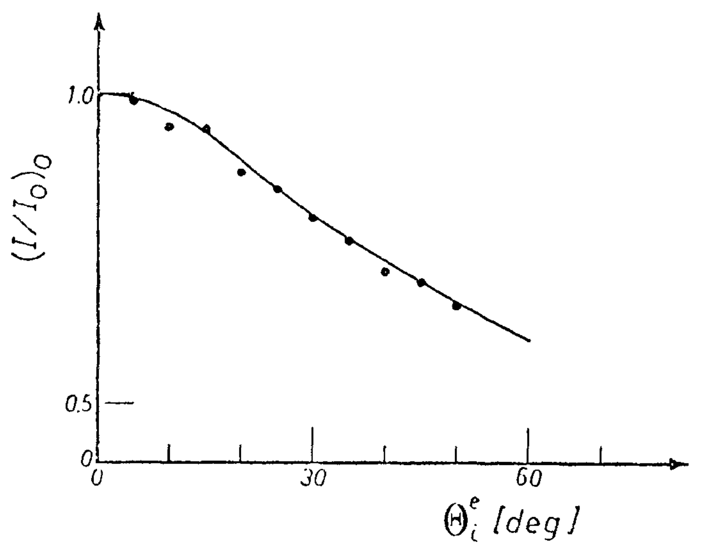


Fig. 2 - Points are experimental and full line theoretical. The best fit values are $K_{II} = 5.9\ IO^{-7}$; $K_{22} = 4.0\ IO^{-7}$; $K_{33} = 7.7\ IO^{-7}$ dyne

dependent on the chosen polarization states and incidence angles.

The errors in the Y_i's are estimated to be 2% or less; for the extraordinary beam and with our choice of angles ϑ_i^e the K_{jj}'s error result about 15%, while for the ordinary beam the error is always larger. The values reported in Fig. 2 have been obtained from the extraordinary curve.

REFERENCES

1. Hiroaki Usui, Hideo Takezoe, Atsuo Fukuda and Eiichi Kuze - Jpn. J. Phys., 18, 1599 (1979).
2. E.Miraldi, C.Oldano, P.Taverna Valabrega and L.Trossi - Proceedings of the Sixth Intern.Conf. on Noise in Physical Systems, Washington 1981 p.339.
3. E.Miraldi, C.Oldano, P.Taverna Valabrega and L.Trossi - Il Nuovo Cimento, 66B, 179 (1981).
4. D.Langevin and H.A. Bouchiat - J.Phys.C (Paris), 36, 197 (1975)
5. E.Miraldi, C.Oldano, P.Taverna Valabrega and L.Trossi - Il Nuovo Cimento, 60B, 165 (1980).