KENT STATE UNIVERSITY LCI® & CPIP
Liquid Crystal Institute®
Chemical Physics Interdisciplinary Program

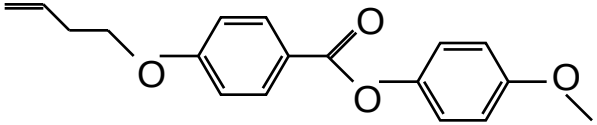
Determination of refractive indices of liquid crystal elastomer

Israel Lazo, Jeremy Neal and Peter Palffy-Muhoray
Liquid Crystal Institute, Kent State University, Kent OH, 44242

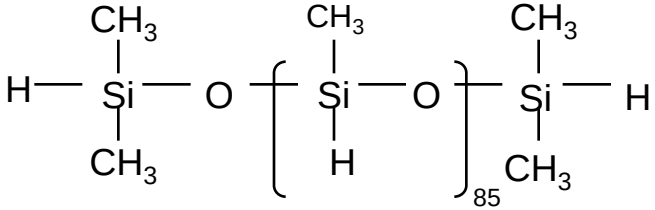
Motivation and Objectives

- Understand the physical properties of this new materials
- Measure the individual refractive indices of a nematic liquid crystal elastomer
- Determine how this refractive indices change as a function of strain

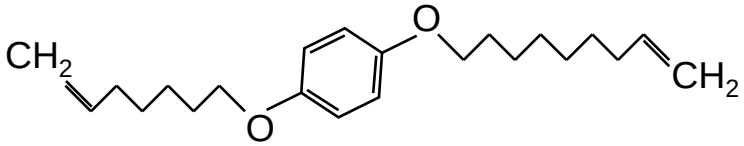
LC elastomer



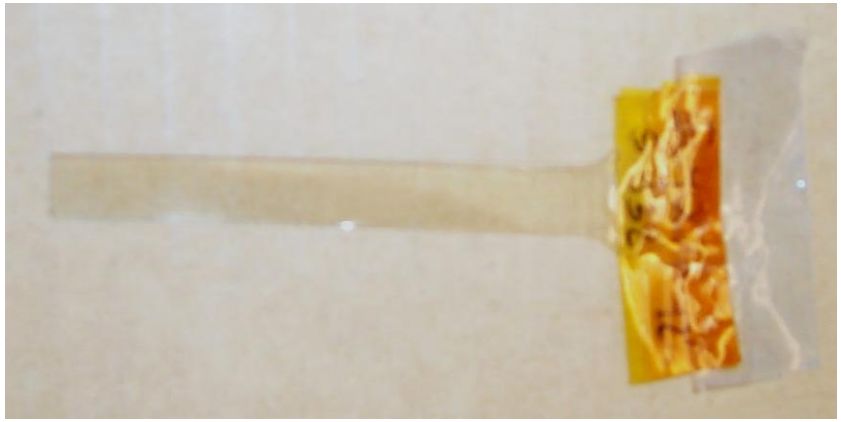
Mesogen

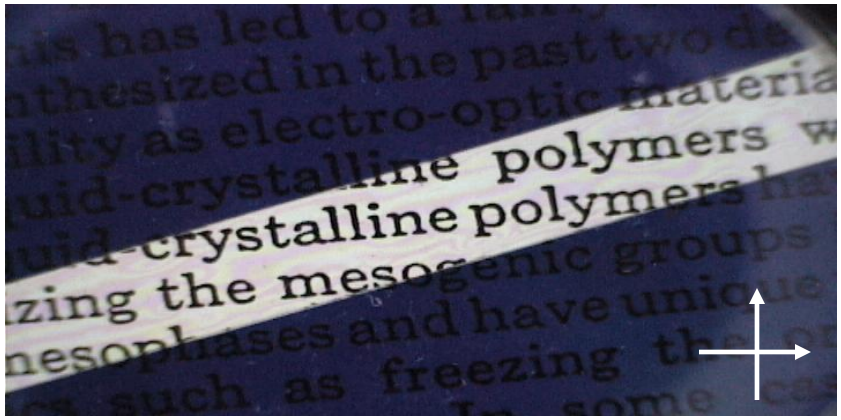


Backbone

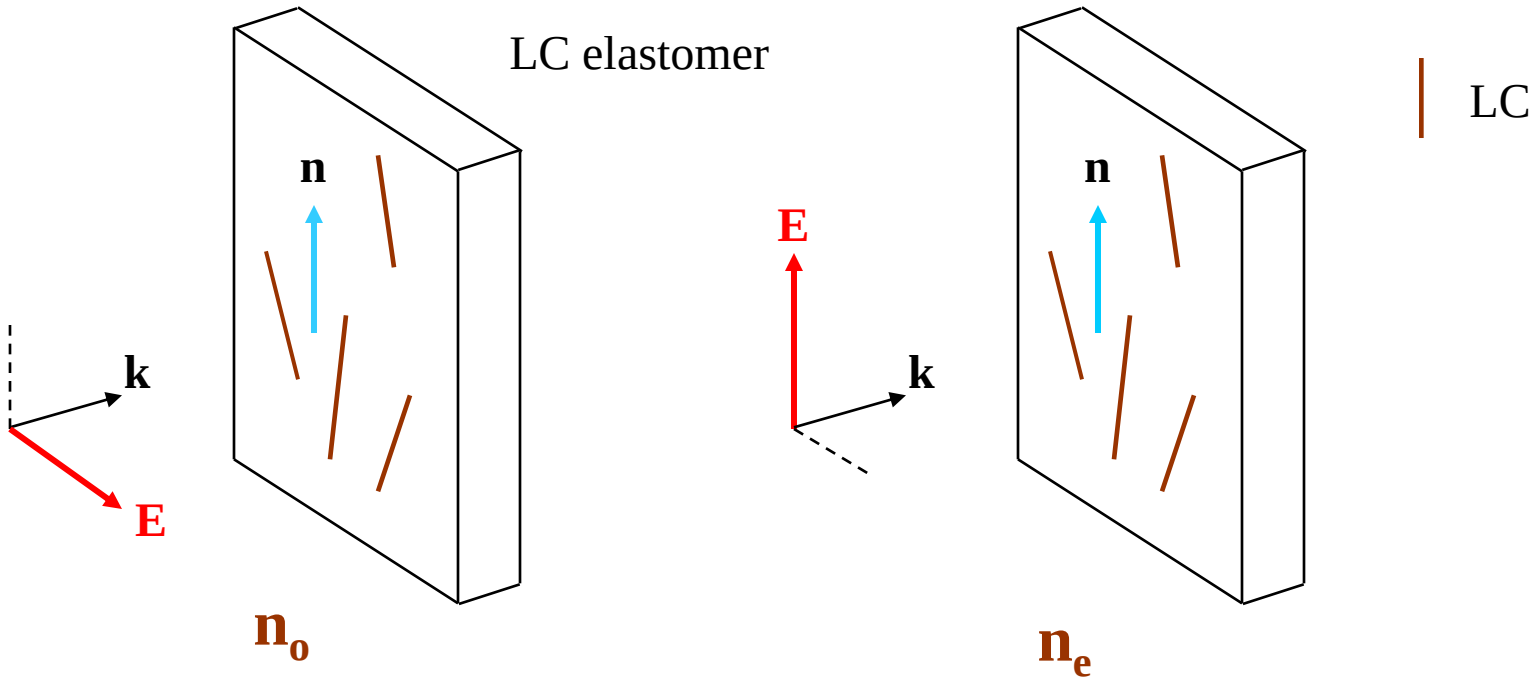


Crosslinker





Refractive indices

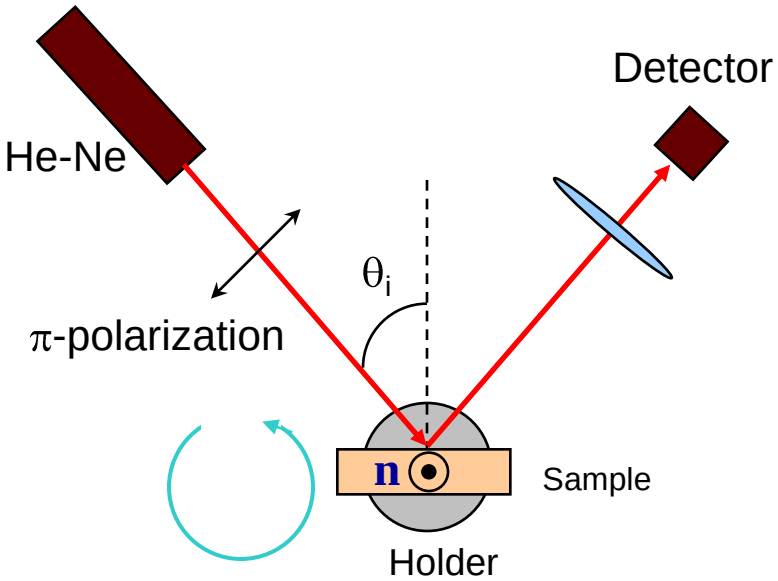


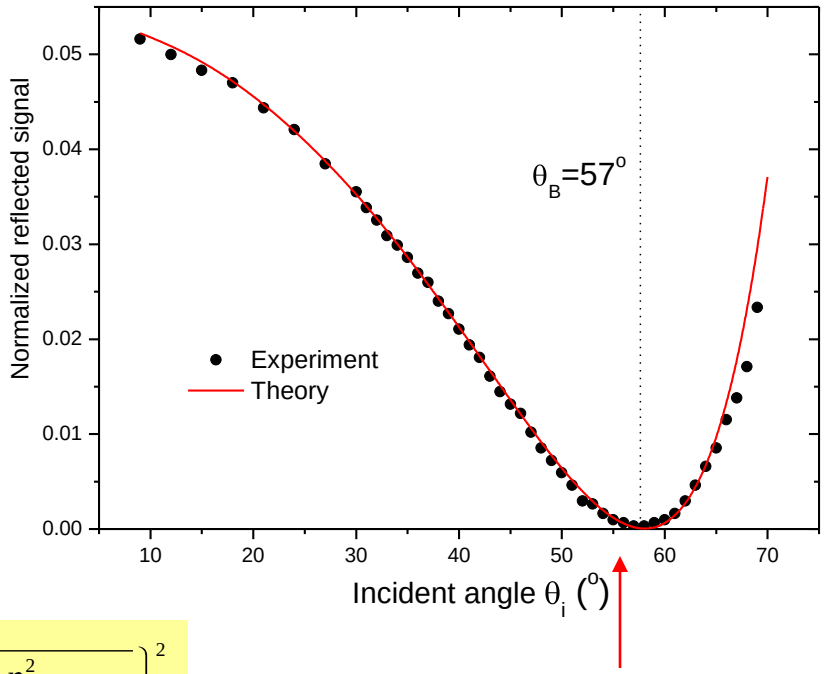
Techniques:

Brewster's angle measurement

Interferometry

Brewster's angle



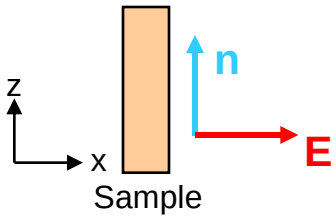


$$R = \left\{ \frac{n_1 \cos\theta_i - n_2 \sqrt{1 - \frac{n_1^2}{n_2^2} \sin^2\theta_i}}{n_1 \cos\theta_i + n_2 \sqrt{1 - \frac{n_1^2}{n_2^2} \sin^2\theta_i}} \right\}^2$$

Brewster's angle!

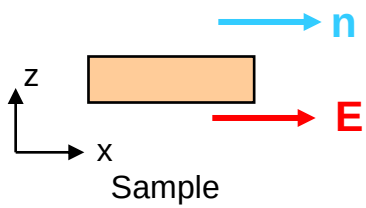
Schematic diagram of the experimental setup for Brewster's angle measurements

Brewster's angle (Model)



Vertical configuration

$$n_0 = \tan\theta_{BV}$$

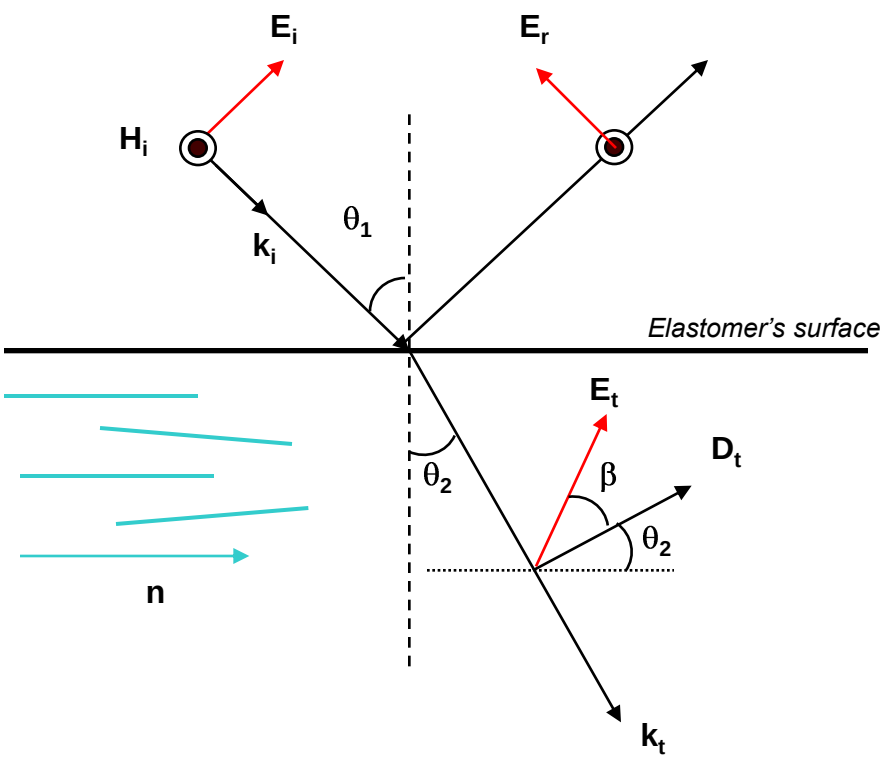


Horizontal configuration

$$n_e = \sqrt{1 + \left[1 - \left(\frac{1}{n_o}\right)^2\right]\tan^2\theta_{BH}}$$

pv

Mathematical model



$$r = \frac{n_2 \cos\theta_1 - n_1 \dfrac{\cos(\theta_2 + \beta)}{\cos\beta}}{n_2 \cos\theta_1 + n_1 \dfrac{\cos(\theta_2 + \beta)}{\cos\beta}}$$

$$\tan\beta = \frac{(n_e^2 - n_o^2)\sin\theta_2 \cos\theta_2}{n_e^2 \sin^2\theta_2 + n_o^2 \cos^2\theta_2}$$

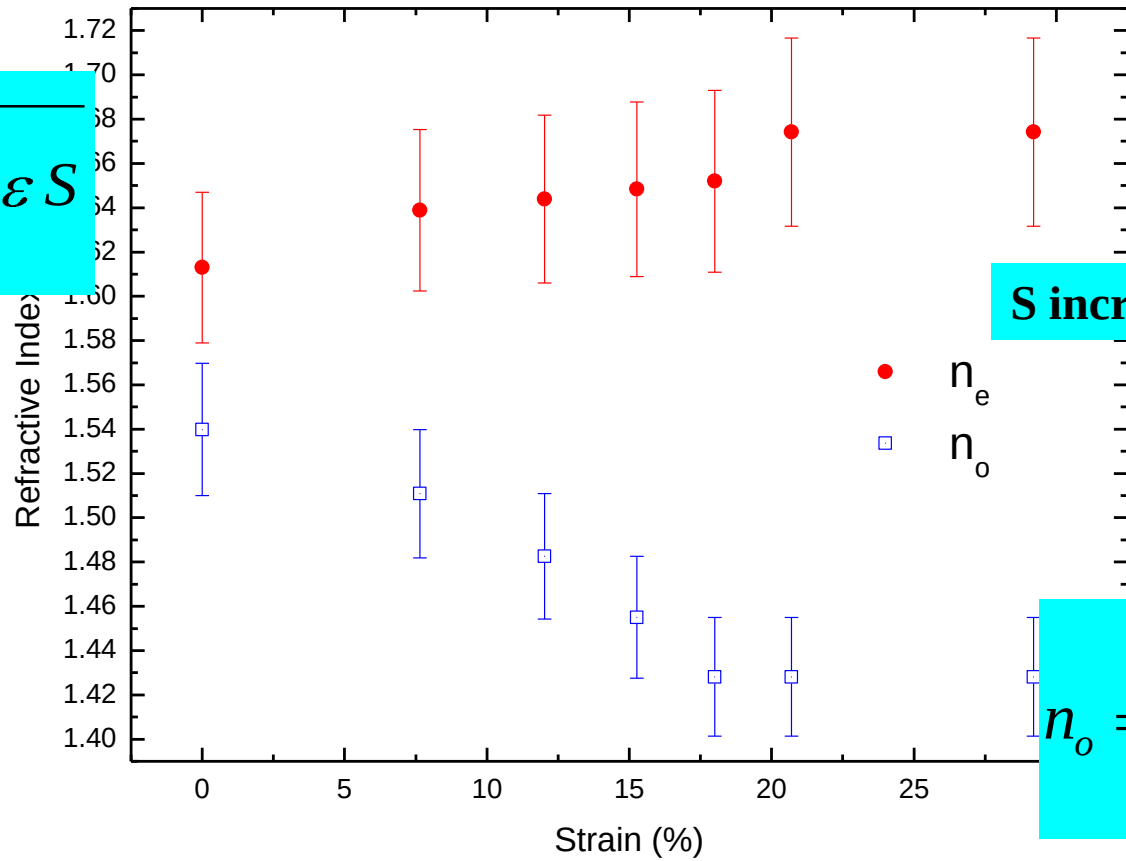
$$n_2 = \frac{n_e n_o}{\sqrt{n_e^2 \sin^2\theta_2 + n_o^2 \cos^2\theta_2}}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

s

Results

$$n_e = \sqrt{\bar{\varepsilon} + \frac{2}{3}\Delta\varepsilon S}$$

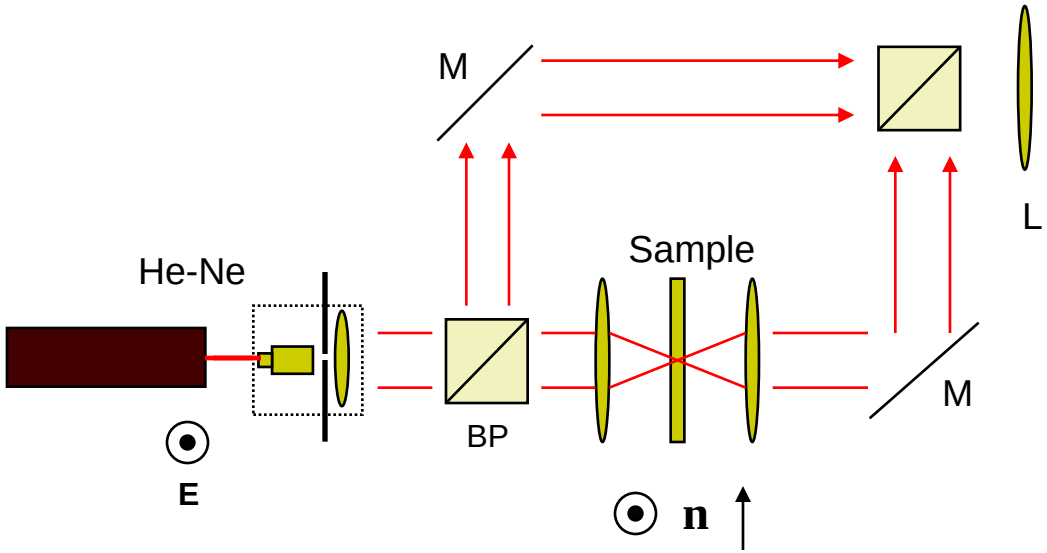


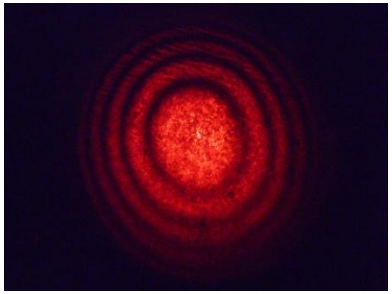
S increases with strain

$$n_o = \sqrt{\bar{\varepsilon} - \frac{1}{3}\Delta\varepsilon S}$$

Experimental results for Brewster's angle technique

Interferometry



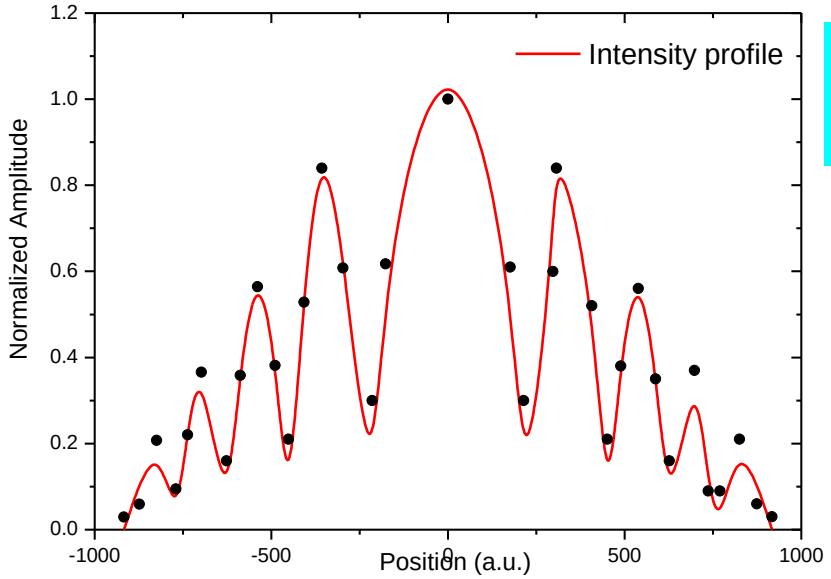


M: Mirror

L: Lens

Schematic diagram of the experimental setup for conoscopic interferometer

Interferometer



Phase shift

$$\Delta\varphi = \frac{2\pi d}{\lambda}\left\{-n_2 - \cos\theta_i + \sqrt{n_2^2 - \sin^2\theta_i}\right\}$$

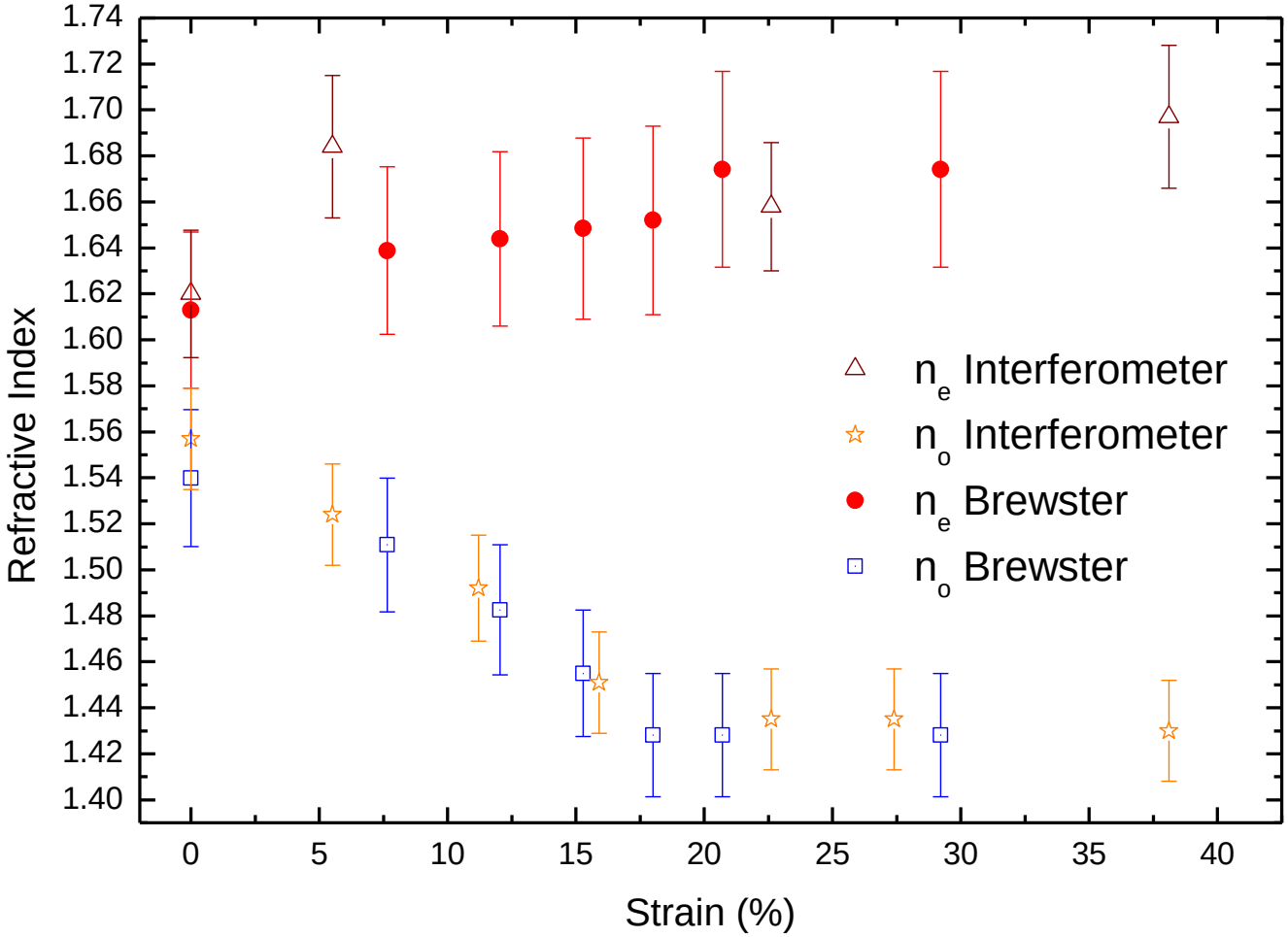
Ordinary refractive index

$n_o \rightarrow n_2$

Special consideration must be taken when calculating n_e

$$n_2 = \frac{n_e n_o}{\sqrt{n_e^2 \sin^2\theta_2 + n_o^2 \cos^2\theta_2}}$$

$$\theta_2 = \tan^{-1}\left\{\sqrt{\frac{n_o^2}{\left(\frac{n_o\, n_e}{\sin\ \theta_i}\right)^2 - n_e^2}}\right\}$$



Experimental results for Interferometer and Brewster's angle techniques

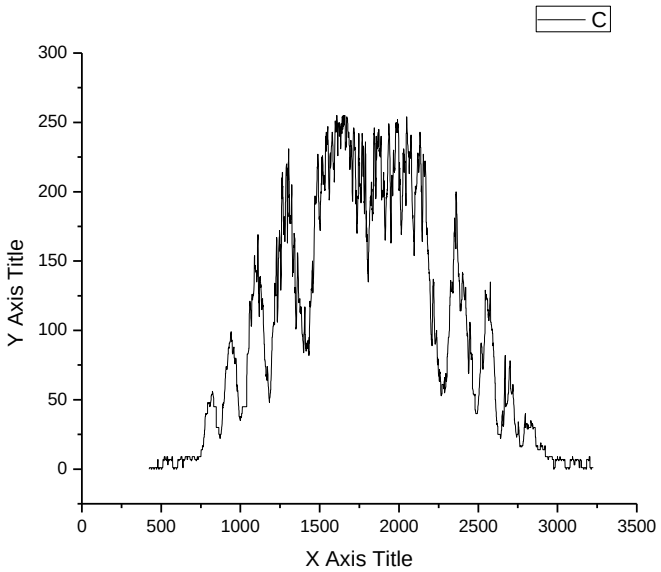
Conclusion

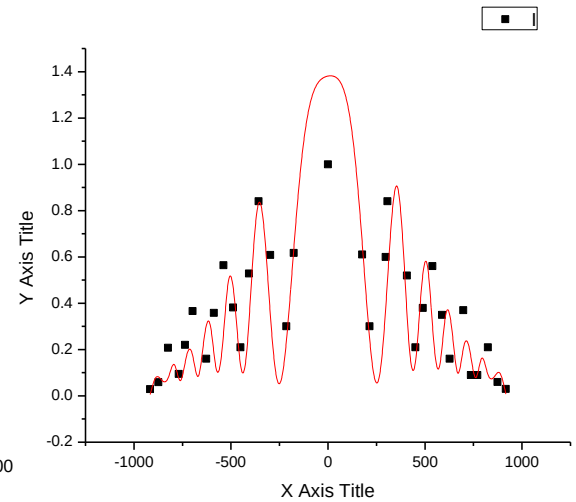
We have measured the ordinary and extraordinary refractive indices of a nematic liquid crystal elastomer using two different methods

Two methods are in a good agreement

To do

Confirm and interpret the results.





Data: Sheet1_I
Model: interference
Equation:
A*exp(-0.5*((x-xc)/w)^2)*B*cos(x^2*a/b)^2
Weighting:
y No weighting

Chi^2/DoF = 0.03788
R^2 = 0.42984

A	0.72524	±0
w	-414.23236	±0
xc	19.62006	±0
B	2153.78282	±0
a	0.00583	±0.00024
b	237.34718	±9.94937