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INVESTIGATION OF THE KERR EFFECT ON POLARISED LIGHT

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ABSTRACT

A constructed Kerr cell with brass electrodes and liquid nitrobenzene was used for studying the Kerr effect on polarised light. Laser light was plane polarised and passed through an energised Kerr cell. The plane polarised light after travelling a path length equal to the cell electrode length in a birefringent medium, suffered optical retardance before passing through an analyser which then transmitted light of certain intensity to a photodiode. Data used were generated from experiments and theoretical considerations using Kerr's law and Malus' law. With crossed Polaroids, the Kerr cell behaved as an electro-optic shutter and the maximum light intensity transmitted rose steadily with increased phase difference to about 0.82. With parallel Polaroids, the maximum light intensity transmitted was higher and found to be 0.89 at zero phase difference. This value indicates a large phase delay and decreased to a non-zero value. At maximum electric field intensity, a 'climbing' of the nitrobenzene on the Kerr cell walls and electrodes was observed with more nitrobenzene attracted to the anode. The effect suspected to be of electrostatic origin may have been driven by the predominant ions in the nitrobenzene. Furthermore, the higher level of the nitrobenzene meniscus at the anode probably suggests that while the cathode injected carriers of negative charge into the liquid the injection of carriers from the anode was weaker. For better results, attention should be given to Polaroid quality, the purity of the liquid nitrobenzene and the length of the electrodes used.

Keywords: electro-optics, birefringence, non-linear optics, anisotropic medium, Polaroids

INTRODUCTION

Kerr effect is an electro-optic effect which shows how light interacts with a birefringent medium to produce effects which engineers and scientists involved in photonics can build on to create new technologies and products. The important position which Kerr effect occupies in the growing science of electro-optics and its intimate connections with the subject of birefringence, has made it an attractive phenomenon for investigation (Kerr,1875; Jenkins and White, 2001). Kerr effect described as the quadratic variation of the refractive index of a medium using an electric field (Klein and Furtak, 1982; Vaziri, 2015) is also a non-linear interaction of light with a medium (Peatross and Ware, 2015; Boyd, 2007) which produces non-linear electronic polarization or induced birefringence. The outcome of studies of light propagation through an anisotropic medium like a Kerr cell, can be tailored to many useful applications (Stolen and Ashkin, 1973) such as the spectroscopy of liquids, studies of liquid mixtures as well as liquid behaviour in Nano confinement (Moreno, 2018; Zhong and Fourkas, 2008). Kerr effect creates changes in the refractive index of a material or medium (Moreno, 2018) and with increased optical power can be used for optical parametric amplification and optical computing (Tse and MacDonald, 2010). Kerr effect has also been applied in technologies used in telecommunication, and in optical switching, optical modulation, (Arivuoli, 2001) as well as in various arms of science and engineering (Hassler *et al*., 2002). Varying the voltage applied to a Kerr cell electrodes results in light passed through it experiencing an optical phase change and with large phase delays increased optical intensity can be obtained (Edwards, 1970). The Kerr effect can attain saturation at very high optical intensities (Loriot *et al*., 2009) and the voltage applied to a Kerr cell electrodes as well as the type of material used for its electrodes are factors which could affect the Kerr cell performance (Song and Guo, 2014).

A number of Kerr effect studies are ongoing and Kerr-type non-linear dielectrics are now being investigated for their abilities to focus light and for optical bistability (Song and Guo, 2014).

Kerr effect works for any light source provided it is monochromatic or made to be so. This research used a laser source of light because it gives an intense monochromatic light and when passed through an anisotropic medium can impose on itself a phase modulation (self-phase modulation) which can be employed in optical fibre communication systems (Agrawal, 2007; Okuno *et al*., 1999), as well as in optical signal processing (Li *et al*., (2005).

Substances which show Kerr effect are singly refracting (Čada *et al*., 2013) but with the application of an electric field, their molecules get re-oriented, acquire anisotropic refracting properties and become birefringent. Some examples include uniaxial crystals like quartz and calcite (Pascal *et al*., 2011; Peatross and Ware, 2015).

Kerr effect first discovered for glass has now been found to occur in liquids like nitrobenzene, nitrotoluene, carbon disulphide and in gases too (Philip and Rao, 2001). Though Kerr effect techniques can be used in studying electric field distribution and for controlling field investigation to enhance the working field strength (Cassidy and Cone, 1969), they have also been employed for space charge measurements and for electric field distortion studies (Song and Guo, 2014). Furthermore, Kerr effect investigations provide a better understanding of how optical fibres work, are important in current scientific researches where ultra-fast signals are needed for data processing (*Ö*sterberg, 1995) and can in future pave the way to many other applications.

In view of the above synopsis, this present research is interested in the Kerr effect on polarised light. A Kerr cell containing nitrobenzene in between brass electrodes was placed in between two dichroic polarizers (Polaroids) chosen because of their preferential absorbance of polarisation (Wyatt, 1978). While one of the Polaroids acted as a polarizer of the

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laser light used, the other Polaroid analysed the output of the light transmitted after passage through the Kerr cell. When some voltage is applied to a Kerr cell, birefringence is induced in the nitrobenzene medium, and the laser light which gets plane polarised by the first polaroid passes through this anisotropic medium and is split into two rays namely an ordinary ray (O'ray) and an extraordinary ray (E'ray) (Bhat, 2016). A phase difference δ occurs between these two rays and for a fixed separation between the Kerr cell electrodes, this phase difference δ is proportional to the square of the electric field applied and gives a measure of the induced birefringence (Bhat, 2016). Furthermore, this phase difference can impact on the light intensity which eventually gets transmitted to the photodiode by the analyser.

In this work, the variation of phase difference δ with the transmitted light intensity I_1 for varied electric field strengths and the response of the calibrated photodiode to transmitted light intensity for crossed and parallel Polaroids were studied. The maximum light intensity for each of these configurations was also obtained and the effectiveness of the chosen Kerr cell liquid in producing the Kerr effect was studied. Kerr's law and Malus' law were used for generating the experimental and theoretical data respectively.

MATERIALS AND METHODS

Materials

A Kerr cell (Figure 1) was constructed using Pyrex glass of thickness 0.5 cm and the coupling of the glass cell was done using Araldite glue. The cell of dimensions $10\ cm \times 3.5cm \times 5cm$ had brass electrodes which were $3.0\ mm$ apart and of dimensions $10cm \times 3cm \times 0.05cm$. The electrodes were of same metal (brass) so that when the polarity of the pulse voltage is changed, the polarity of the injected space charge and hence the emission ability of the space charge between the electrodes can be impacted (Song and Guo, 2014). The brass electrodes were properly cleaned with emery cloth and connecting wires were soldered unto them before they were placed in the Kerr cell as shown in Figure 1.

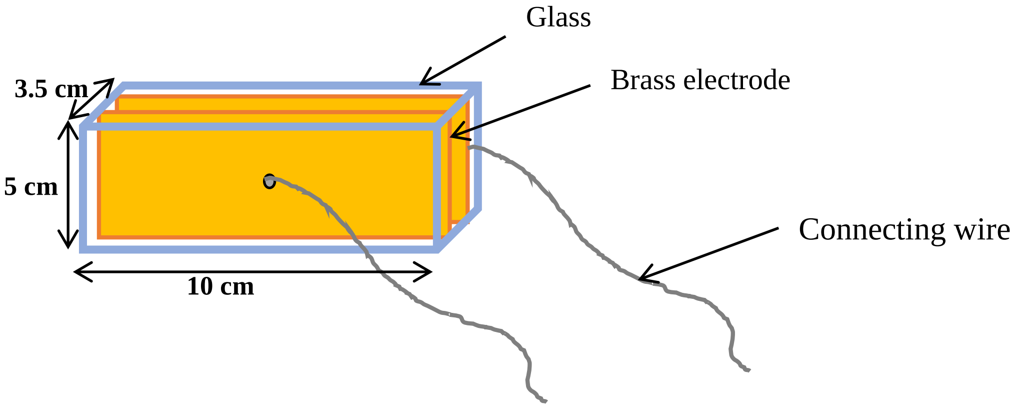
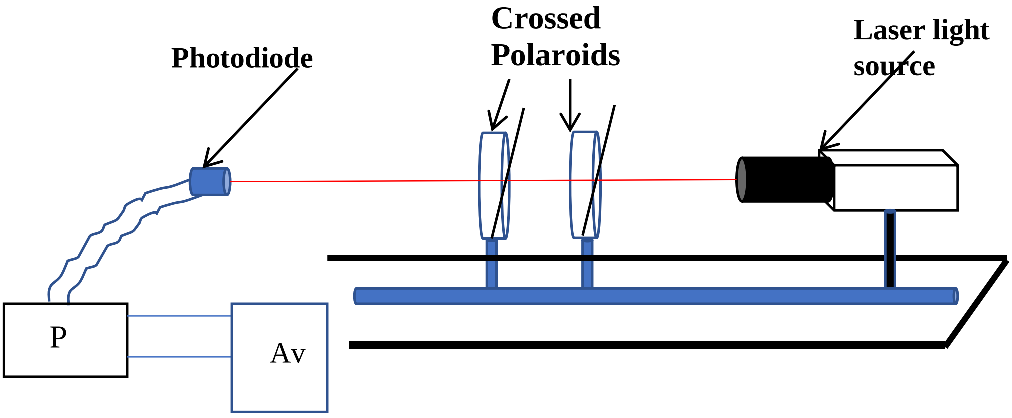


Figure 1: Constructed Kerr cell

The Kerr cell liquid used (nitrobenzene) was a pale-yellow polar organic liquid of Kerr constant $2.442 \times 10^{-16}\, mV^{-2}$ of analytical grade (ANALAR) suitable for light of wavelength 5893 Å. A voltage source (Griffin & George Ltd product) with specifications 5 kV, 3mA and two Polaroids were used with one of the Polaroids acting as a polarizer, and the other an analyser.

A photodiode connected to a photodiode amplifier (PA) (Figure 2), acted as a light detector for the light emerging from the analyser while an Avometer (Av) connected to the photodiode amplifier (PA) was used for reading the photodiode current in Volts. A He-Neon laser of wavelength 632.8 nm was chosen for this work because it provides a stable monochromatic light source capable of emitting a continuous intense highly parallel beam of small diameter (Lenz and Zimmermann, 2000). Before commencing the experiment, the laser light was switched on for about an hour to get it to its equilibrium in power emission.

Figure 2: Set up for calibration of photodiode



Calibration of photodiode

The set-up which was used for calibrating the photodiode to study its response to varying light intensities from the analyser was as shown in Figure 2. Light from the monochromatic laser source travelled through the crossed Polaroids and by varying the angle of the analyser, light of varied intensities was received by the photodiode. The response of the photodiode to varying light intensities was read off from the Avometer in volts and the results obtained are as displayed in Table

1. Light from the laser source arrives at the first Polaroid and gets plane polarised. This light which then passes through the second Polaroid (the analyser) has two components, (one of amplitude A_1 parallel to the transmission plane of the analyser and the other A_2 which is perpendicular to this plane) but only the A_1 component gets transmitted by the analyser as illustrated in Figure 3.

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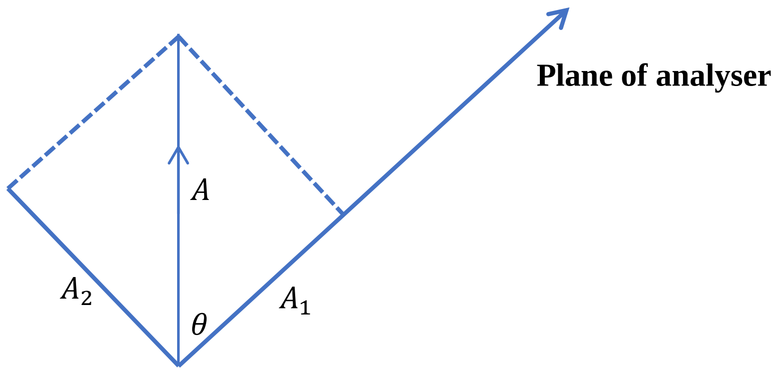

Figure 3: Resolution into components of the amplitude of plane polarised light

The amplitude of the transmitted ray A_1 is proportional to the cosine of the angle of the analyser thus,

$$A_1 = A\ Cos\ \theta \qquad (1)$$

The intensity of light transmitted by the analyser according to Malus' law (Collett, 2005) is given by:

$$I_1 = A^2 Cos^2\theta = I_0\ Cos^2\theta \qquad (2)$$

(Where I_0 the intensity of the incident polarised light).

Thus from equation (2) above, I_1 is proportional to $Cos^2\theta$.

Therefore, by reading the voltage of the photodiode (which is the current equivalent), for different angles of the Analyser θ, a graph of the photodiode voltage V against $Cos^2\theta$ gave the calibration curve for the photodiode (Figure 4) and all other data were derived from this curve. Thus, for any configuration (crossed or parallel Polaroids), the experimental data was derived by reading from the photodiode calibration curve the light intensity for each measured photodiode voltage (V).

Table 1: Variation of Photodiode current for different angles of the Analyser θ

Photodiode current(Volts)	**Angle of analyser θ_1**	**Angle of maximum intensity (reference point) θ_2**	$\boldsymbol{\theta = (\theta_2 - \theta_1)}$	**Intensity of polarised light $Cos^2\theta$ (arbitrary units)**
0.60	112	205	93	0.002
0.65	120	205	85	0.007
1.15	130	205	75	0.066
2.20	140	205	65	0.178
3.70	150	205	55	0.328
5.62	160	205	45	0.500
5.85	170	205	35	0.671
5.85	180	205	25	0.821
5.85	190	205	15	0.933

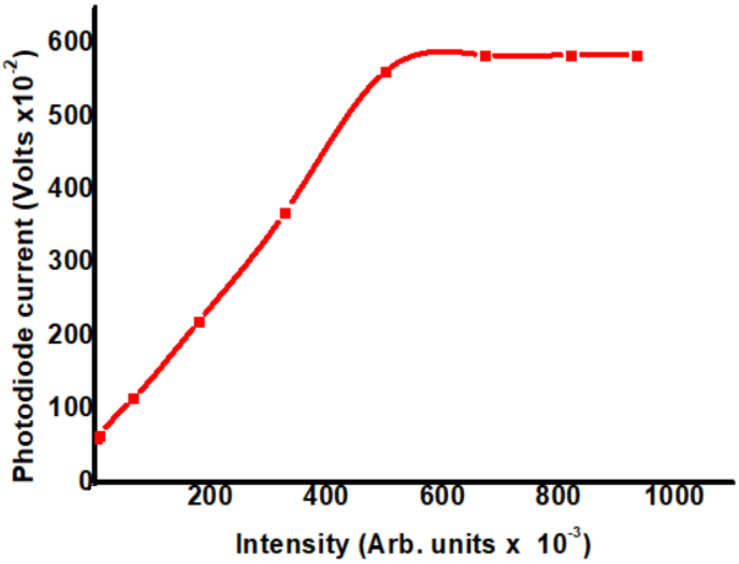

Figure 4: Photodiode calibration curve

The calibration curve of the photodiode shows that the photodiode current increased with the intensity of light transmitted by the analyser up to a certain maximum value and gets to saturation as shown by the flattening of the curve.

After calibrating the photodiode, the nitrobenzene was poured into the Kerr cell which was then placed in between the Polaroids (Figure 5). With the Kerr cell electrodes and other components connected as shown, light from the laser was shone through the Kerr cell and when the angle of the analyser was varied, no Kerr effect was observed. The Kerr cell resistance was then measured and found to be 120 $k\Omega$ implying that a current of 33 mA was available. The high voltage source connected to the Kerr cell electrodes also showed 0.5 kV which was far below 4 kV required for the cell to respond as a half wave plate, With these observed limitations, the purity level of the nitrobenzene was queried, and had to be addressed.

Purification of the Kerr cell liquid (Nitrobenzene)

The nitrobenzene was purified by mixing 150 ml of the nitrobenzene with 20 ml of 10 % Na_2CO_3 solution and shaking the mixture in a separating funnel and thereafter collecting the lower layer in a conical flask. This process was repeated thrice after which the nitrobenzene was washed with water and dried with calcium chloride in a stoppered flask. After filtering out the calcium chloride, the nitrobenzene was subjected to air distillation (Finar, 1964). This process was repeated till the boiling point of the obtained distillate (pure nitrobenzene) was about 211 ℃. The purified nitrobenzene was then poured into the Kerr cell and the cell resistance was measured and found to be 800 $k\Omega$. As earlier mentioned, this Kerr cell required a voltage of about 4 kV to function as a half wave plate therefore with these values of resistance and voltage , a current of about 5 mA which is close to that of the voltage supply was obtained. With the nitrobenzene now purified and poured into the Kerr cell placed in between the Polaroids and with all necessary connections made the outcome was positive.

Kerr effect on polarised light

The purified nitrobenzene was poured into the Kerr cell and placed in between the two Polaroids. The Kerr cell was connected to the high voltage source while the photodiode was connected to the amplifier and the Avometer (Av) as shown in Figure 5. Light from the laser source passes through the polariser and emerges as a linear vibration inclined at an angle of 45 °. The plane polarised light then enters the energised Kerr cell and gets elliptically polarised but the analyser will only allow light in one direction to pass through as already explained.

The Kerr effect on the polarised light was studied for two cases: (i) for crossed Polaroids and (ii) for parallel Polaroids. In each case, theoretical and experimental data were obtained and plotted.

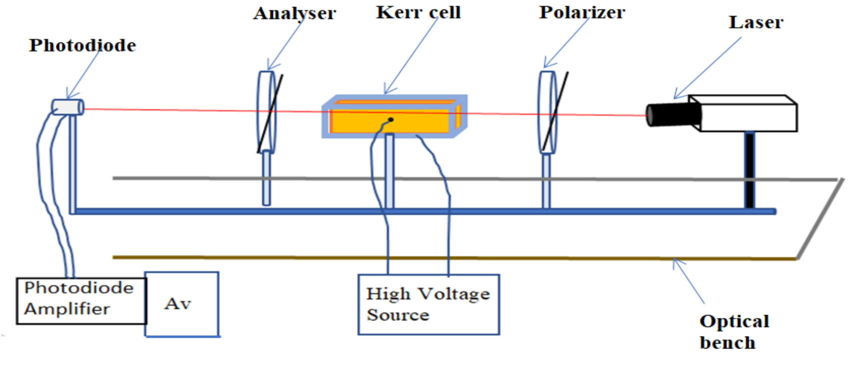

Figure 5 : Set up for Kerr effect studies

Theory of experiment

When plane polarised light passes through the nitrobenzene medium in between the Kerr cell electrodes in a direction parallel to their planes, it is subjected to optical retardance and emerges as elliptically polarised light. The retardance behaviour as summarised in Kerr's law is given in equation (3) (Stolen and Ashkins, 1973):

$$\Delta\varphi = \frac{2\pi k l E^2}{d^2} \qquad (3)$$

(l is the effective length of the cell electrodes separated a distance d and E is the applied electric field in volts; k is Kerr's constant)

For this Kerr cell to function as a half wave plate which introduces a relative phase difference of π radians or 180 ° between the O' and E' rays, the retardance $\Delta\varphi = \pi$.

The voltage which the Kerr requires to function as such can be obtained using the equation:

$$E = \sqrt{\frac{d^2}{2kl}}$$

From the specifications of the constructed Kerr cell, this was calculated to be approximately $4\,kV$.

The path difference Δ between two vibrations in a Kerr cell is proportional to the path length (which in this case is the length of the Kerr cell electrode l), and to the square of the Electric field strength E therefore:

$$\Delta = \frac{K l E^2 \lambda}{d^2} \qquad (4)$$

The phase difference δ between the two vibrations described above is given by:

$$\delta = \frac{2\pi}{\lambda}\,\Delta \;= \frac{K 2\pi l E^2}{d^2} \qquad (5)$$

If the vibrations parallel and perpendicular to the electric fields are E_x and E_y for the E$'$ and O' rays respectively and are described by:

$$E_x = E_1 Cos\ \omega t \qquad (6a)$$

$$E_y = E_1 Cos\ \omega t \qquad (6b)$$

On entering the Kerr cell, a path difference δ is introduced such that :

$$E_x = E_1 Cos\ (\omega t + \delta) \qquad (7)$$

$$E_y = E_1 Cos\ \omega t \qquad (8)$$

(This phase difference could however be associated with any of the rays.)

In the light of the above, two cases namely: when the Polaroids are (i) Crossed and (ii) Parallel were studied.

(i) *Crossed Polaroids*

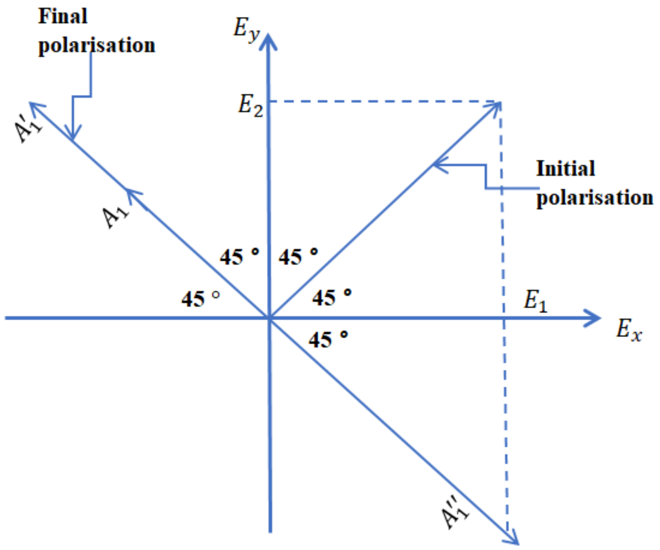

Figure 6 : Light vibrations parallel and perpendicular to electric field $\boldsymbol{E_x}$ and $\boldsymbol{E_y}$ for the E' and O' rays respectively

When the Polaroids are crossed, the amplitude of the waves is given by:

$$A_1' = \frac{E_y}{Sin\ 45} = \sqrt{2}\,E_y \qquad (9a)$$

$$A_1'' = \frac{E_x}{Sin\ 45} = \sqrt{2}\,E_x \qquad (9b)$$

The time average intensity of the transmitted light is:

$$\overline{A_1^{\ 2}} = 2\overline{E_x^{\ 2}} + 2\overline{E_y^{\ 2}} - 4\overline{E_xE_y} \qquad (10)$$

But $\quad 2\overline{E_x^{\ 2}} = 2E_1^{\ 2}\overline{Cos^2(\ \omega t + \delta)} \quad = E_1^{\ 2}$ (10a)

Similarly $\quad 2\overline{E_y^{\ 2}} = 2E_1^{\ 2}\overline{Cos^2\ \omega t} \quad = E_1^{\ 2}$ (since $\overline{Cos^2\omega t} = \frac{1}{2}$) (10b)

$$E_xE_y = E_1^{\ 2}\{Cos(\omega t + \delta)Cos\omega t\} \qquad (10c)$$

Applying product to sum formula to equation (10c) gives:

$$E_xE_y = \frac{E_1^{\ 2}}{2}\{Cos\ \ \delta + Cos(2\omega t + \delta)\}$$

$$4\overline{E_xE_y} = E_1^{\ 2}\ \{Cos\ \ \delta + Cos\overline{(2\omega t + \delta)\}} \ = 2E_1^{\ 2}\ Cos\ \delta \qquad (10d)$$

(Since $Cos\overline{(2\omega t + \delta)} = 0$)

Substituting (10a - 10d) into (10) gives:

$$\overline{A_1^{\ 2}} = 2E_1^{\ 2} - 2E_1^{\ 2}\ Cos\ \delta$$

$$\overline{A_1^{\ 2}} = 2E_1^{\ 2}(1 - Cos\ \delta)$$

$$\overline{A_1{}^2} = 4E_1{}^2 Sin^2\,\frac{\delta}{2}$$

Therefore with crossed Polaroids the total light intensity transmitted from the analyser varies as $Sin^2\,\frac{\delta}{2}$ hence,

$$\overline{A_1{}^2} = A\,Sin^2\,\frac{\delta}{2} \qquad (11)$$

(where A is the maximum value from the experimental graph)

(ii) *Parallel Polaroids*

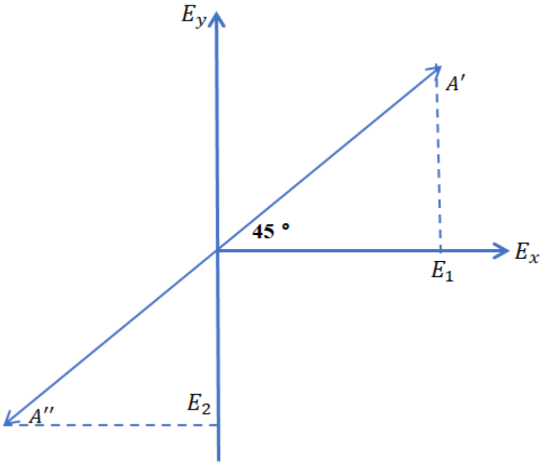

Figure 7

When the Polaroids are parallel,

$$A' = \frac{E_x}{Cos\,45} = \sqrt{2}\,E_x \qquad (12a)$$

$$A'' = \frac{-E_y}{Cos\;45} = \sqrt{2}\,E_y \qquad (12b)$$

The total light intensity A is given by :

$$A = \sqrt{2}(E_x - E_y)$$

The time average intensity for this case is:

$$\overline{A^2} = 2\overline{E_y}^2 + 2\overline{E_x}^2 + 4\overline{E_yE_x} \qquad (13)$$

And $\overline{A^2} = 2E_1{}^2 + 2E_1{}^2 Cos\,\delta$

Or $\overline{A^2} = 2E_1{}^2(1 + Cos\,\delta) \qquad (14)$

And $\overline{A^2} = 4E_1{}^2 Cos^2\,{}^{\delta}/_2$

Showing that $\overline{A^2}\ \alpha\ Cos^2\,{}^{\delta}/_2 \qquad (15)$

Therefore for parallel Polaroids, the light intensity from the analyser varies as $Cos^2\,{}^{\delta}/_2$

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Data for crossed Polaroids

The phase difference δ between the two components of vibrations passing through the Kerr cell is proportional to the square of the electric field.

From equation (5), $\delta = \frac{K2\pi lE^2}{d^2}$ and so for $K = 2.44 \times 10^{-12} mV^{-2}$, $l = 10\ cm$, $\pi = 3.14$, and $d = 3 \times 10^{-3}$, the phase difference $\delta = 1.70 \times 10^{-7} E^2$ radians.

Thus, for different values of E, corresponding values of δ were calculated. Furthermore, since the intensity of light from the analyser is proportional to $Cos^2\theta$ (Equation 2), for each value of the photodiode current (measured in volts) the corresponding light intensity values were read off from the photodiode calibration curve (Figure 4) and the obtained experimental values for crossed Polaroids are displayed in Table 2.

Theoretically, however, the intensity of light falling on the photodiode varies as $Sin^2 \delta/_2$ (Equation 11). From the experimental plot, the maximum light intensity transmitted A was 0.82 (Table 2) so the experimental graph was extrapolated to 0.95 to get more points for the theoretical graph. Derived theoretical values for crossed Polaroids are as shown in Table 3 while Figure 8 shows the experimental and theoretical graphs of the variation of phase difference with light intensity from the analyser for crossed Polaroids.

Table 2: Experimental data for variation of phase difference with light intensity for crossed Polaroids

E(kV)	$\boldsymbol{\delta \times 10^{-2}}$	**Photodiode voltage(V)**	**Intensity $\boldsymbol{Cos^2\theta}$ (Arb units)**
0.0	0.0	0.75	0.035
0.5	4.3	0.85	0.045
1.0	17.0	0.89	0.050
1.5	38.3	1.00	0.066
2.0	68.0	1.45	0.105
2.5	106.3	2.40	0.210
3.0	153.0	4.35	0.410
3.5	208.3	5.90	0.670
3.8	245.5	5.90	0.821

Table 3: Theoretical data for variation of phase difference with light intensity for crossed Polaroids

E(kV)	$\delta \times 10^{-2}$	$\delta/2 \times 10^{-2}$	$Sin^2 \delta/2 \times 10^{-2}$	$ASin^2 \delta/2$
0.0	0.0	0.0	0.0	0.0
0.5	4.2	2.1	0.001	0.001
1.0	17.0	8.5	0.022	0.021
1.5	38.3	19.2	0.108	0.103
2.0	68.0	34.0	0.314	0.298
2.5	106.3	53.2	0.641	0.609
3.0	153.0	76.5	0.937	0.890
3.5	208.3	104.2	0.940	0.893
3.8	245.5	122.8	0.707	0.671

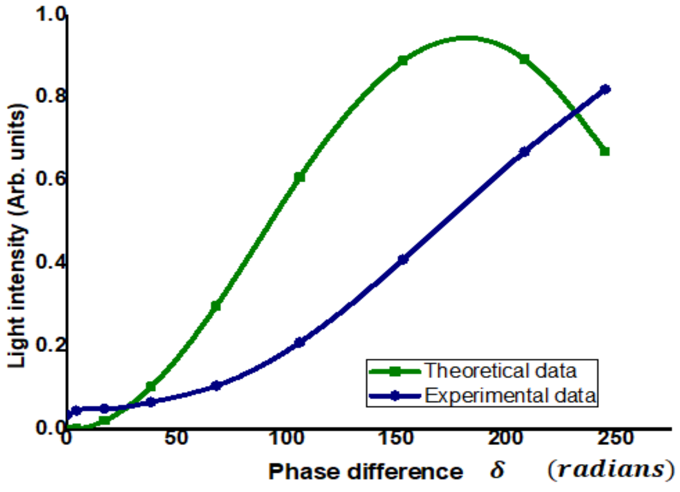

Figure 8: Variation of phase difference with photodiode light intensity for crossed Polaroids

Data for parallel Polaroids

For the parallel Polaroids, the same range of E values as in the case of crossed Polaroids, were used for determining the δ values. Furthermore, and for each photodiode current in volts, the corresponding light intensity from the analyser was read off from the photodiode calibration curve. The obtained experimental data for parallel Polaroids are shown in Table 4.

For the theoretical data, the same range of E, δ, and $\delta/2$ values used for the experimental data was used. Recall that for parallel Polaroids the light intensity from the analyser varies as $Cos^2 \delta/2$. Therefore the obtained theoretical data for parallel Polaroids are as shown in Table 5. The experimental and theoretical graphs of the variation of phase difference with light intensity for parallel Polaroids are as shown in Figure 9.

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Table 4: Experimental data for variation of phase difference with light intensity for parallel Polaroids

E(kV)	$\delta \times 10^{-2}$	**Photodiode voltage(V)**	**Intensity $Cos^2\theta$ (Arb units)**
0.0	0.0	5.85	0.89
0.5	4.3	5.85	0.88
1.0	17.0	5.85	0.87
1.5	38.3	5.80	0.80
2.0	68.0	5.80	0.60
2.5	106.3	3.60	0.30
3.0	153.0	1,10	0.05
3.5	208.3	0.07	0.02
3.8	245.5	0.04	0.01

Table 5: Theoretical data for variation of phase difference with light intensity for parallel Polaroids

E(kV)	$\delta \times 10^{-2}$	$\delta/2 \times 10^{-2}$	$Cos^2 \delta/2 \times 10^{-2}$	A $Cos^2 \delta/2$
0.0	0.0	0.0	1.00	0.89
0.5	4.2	2.1	0.998	0.88
1.0	17.0	8.5	0.978	0.87
1.5	38.3	19.2	0.891	0.79
2.0	68.0	34.0	0.685	0.60
2.5	106.3	53.2	0.357	0.31
3.0	153.0	76.5	0.052	0.05
3.5	208.3	104.2	0.004	0.04
3.8	245.5	122.8	0.001	0.02

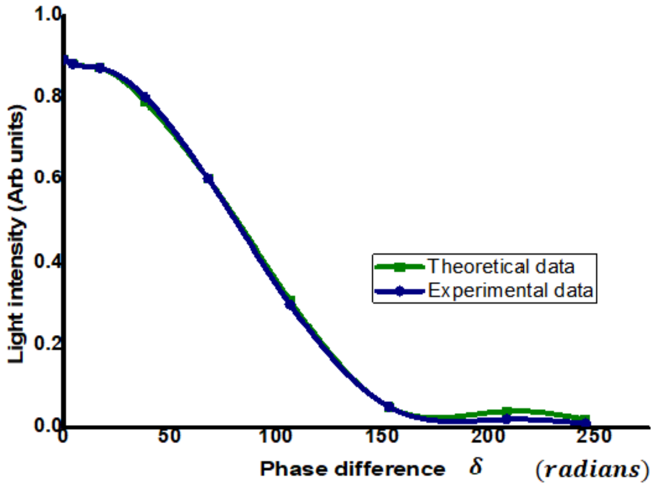

Figure 9: Variation of phase difference with photodiode light intensity for parallel Polaroids.

RESULTS AND DISCUSSION

When the raw nitrobenzene was poured into the Kerr cell and all connections made (Figure 5), adjustments in the angle of the analyser produced no observable Kerr effect. This probably was because the electric field in between the Kerr cell electrodes may have been distorted by impurities in the nitrobenzene some of which may have formed conduction charges in the space between the electrodes imparting to the field a character which was significantly different from the ideal and prompted the purification of the nitrobenzene.

With the Polaroids crossed at 45 ° to the electric field, all light was shut out when the electric field was switched off. However on gradually increasing the electric field, some light was transmitted by the analyser which indicated that the Kerr cell behaved as an electro- optic shutter. When the phase difference was zero, the theoretical curve showed that no light was transmitted. This was contrary to the experimental graph which showed that even at zero phase difference the transmitted light intensity has a non-zero value (Figure 8). This result suggests that either the Polaroids used were not perfect or the photodiode during the experiment may have been picking up some light from its immediate surroundings.

With both Polaroids either parallel or normal, no change was observed when the electric field was either increased or decreased. This might probably be due to the fact that there was no phase difference between the O’ and E’ rays. Thus, when both Polaroids are parallel, only the O’ ray gets transmitted by the analyser and with both Polaroids normal, only the E’ ray gets transmitted. The theoretical and experimental graphs for this case (Figure 9) show that at zero phase difference the transmitted light intensity is a maximum but as the phase difference increased, the light intensity dropped to a non-zero minimum value (Figure 9).

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It was also observed that as the electric field was increased to its maximum possible value, most of the liquid nitrobenzene in the Kerr cell moved from the negative electrode to the positive electrode as shown in Figure 10. This ‘climbing’ of the nitrobenzene on the electrodes and walls of the Kerr cell was similar to that reported by Watanabe (Watanabe, 1973) which was assumed to be due to electrostatic force and this may have been driven by the predominant ions in the nitrobenzene liquid. Furthermore, the level of the meniscus of the nitrobenzene in the Kerr cell was lower at the cathode than at the anode probably because while the cathode injected carriers of negative charge into the liquid the injection of carriers from the anode was weaker (Watanabe, 1973; Ushakov *et al*., 2007; Zahn, 2011).

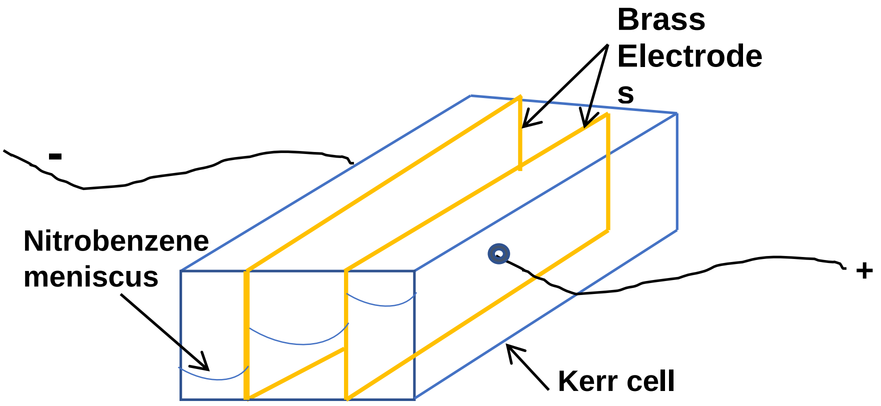

Figure 10: Meniscus of nitrobenzene liquid as it climbs the Kerr cell walls and moves more towards the anode

CONCLUSION

A Kerr cell was constructed and used for studying the Kerr effect on Polarised light for crossed Polaroids and parallel Polaroids. The work confirms the need for a good quality and strong electric field between the Kerr cell electrodes and cautions on the adverse effect of having a distorted electric field in between the cell electrodes. It is therefore important to ensure that ionogenic impurity in the Kerr cell liquid (nitrobenzene) is removed to improve on the conductivity of the nitrobenzene and provide the needed strong electric field for observable Kerr effect. While the maximum light intensity transmitted by the analyser was found to be 0.82 for crossed Polaroids, it was found to be higher at 0.89 for parallel Polaroids. This value for the parallel Polaroids indicates a large phase delay and dropped steadily to a non-zero value. For crossed Polaroids and at zero phase difference, the light transmitted to the photodiode was attributed to either imperfect Polaroids or a possibility that the photodiode used as the light detector was picking up light from its immediate surroundings. It is therefore necessary to ensure that Polaroids used for this kind of experiment are perfect. A better result than the above may be obtained if the experiments are carried out in a dark room and since the intensity of light transmitted by the analyser depends on the path length of light through the Kerr cell, the material used for the Kerr cell electrodes must be carefully chosen.

Generally, the experimental results were found to agree with theoretical predictions and with other reported results from available literature. It is hoped that the result of this study will add to existing knowledge and be useful to researchers in this field who may need transmitted light intensity in the obtained range for some applications.

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