Characterization of Liquid Crystal Variable Retarder

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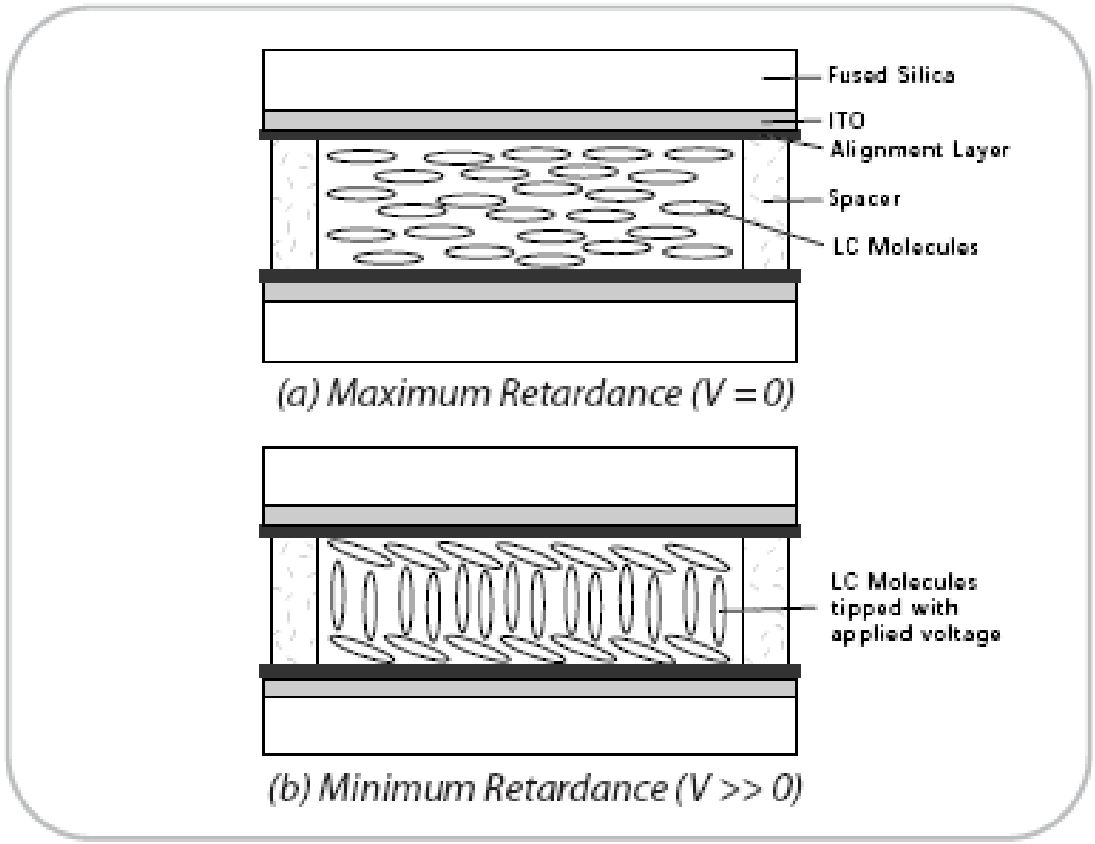
Outline

1. Mechanism of Variable Retarder
2. Experimental setup 1
3. Experimental setup 2 : measurement of retardance
4. Experimental setup 2 : measurement of response time

1. Mechanism of variable retarder

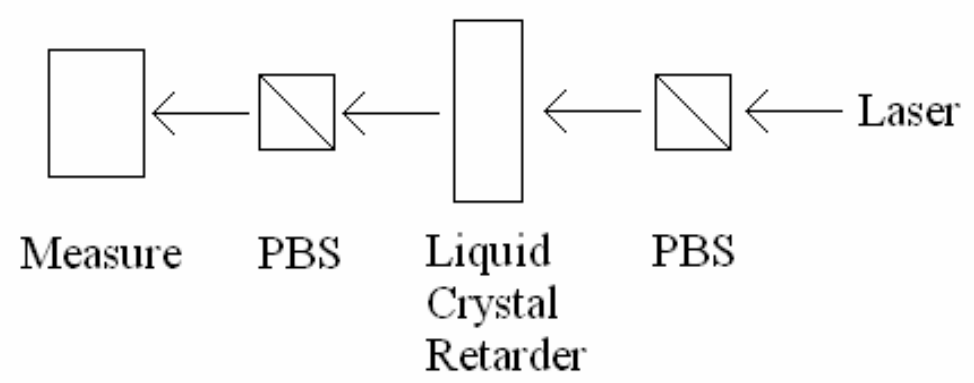
- Product : Meadowlark Optics liquid crystal retarder
- Tunable retarder
  - Retardance : $\Gamma = \frac{2\pi}{\lambda}(n_e - n_o)d$
  - Adjust voltage
  - Change the effective birefringence of the material
  - Alter the polarization of incident light to another elliptical polarization by the amount of retardance
- Use of Liquid Crystal
  - Property : Molecules are aligned with long axes parallel

1. Mechanism of variable retarder



- No voltage
- Voltage applied

2. Experimental setup 1



- Calculation of Intensity
  - Retardance : $\Gamma = \frac{2\pi}{\lambda}(n_e - n_o)d$
  - Electric field : $E' = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \cos(\Gamma/2) & -i\sin(\Gamma/2) \\ -i\sin(\Gamma/2) & \cos(\Gamma/2) \end{pmatrix} E_0 \begin{pmatrix} 0 \\ 1 \end{pmatrix}$
  - Intensity : $I = I_0 \cos^2(\Gamma/2)$

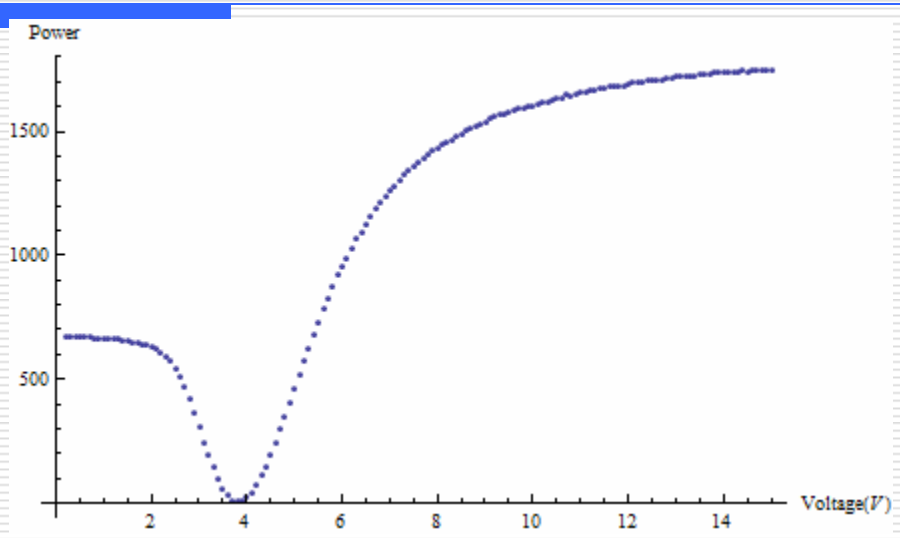
2. Experimental setup 1

- Intensity

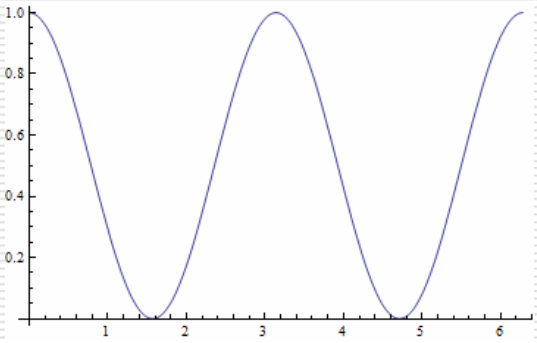
$$I = I_0 \cos^2(\Gamma/2)$$

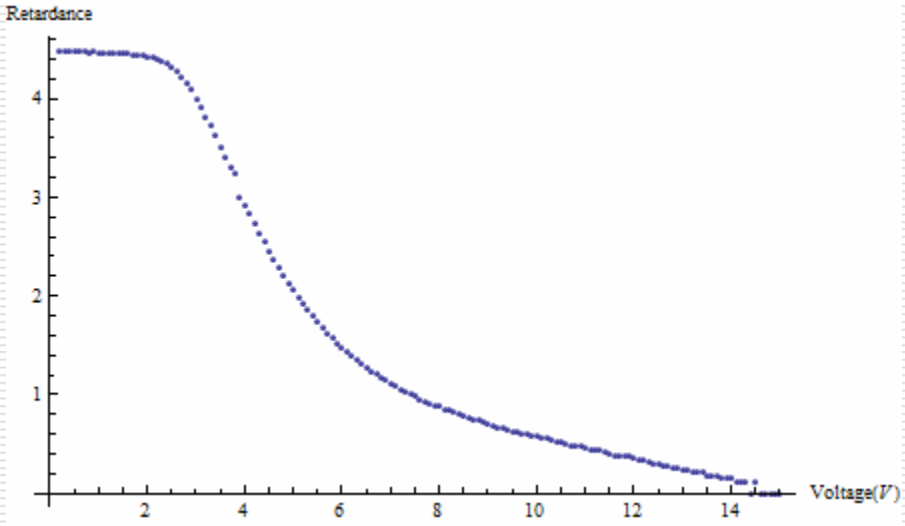
- Retardance

$$\Gamma = 2\cos^{-1}\left(\sqrt{\frac{I}{I_0}}\right)$$



$$\cos^2(x)$$

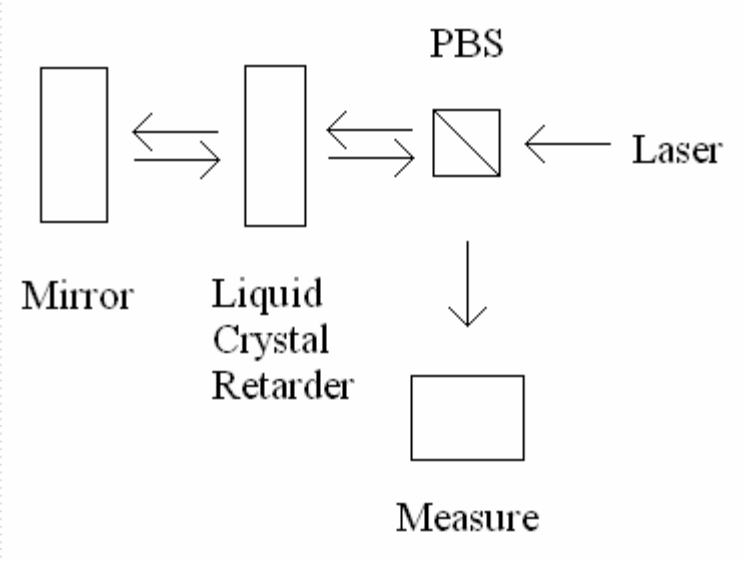


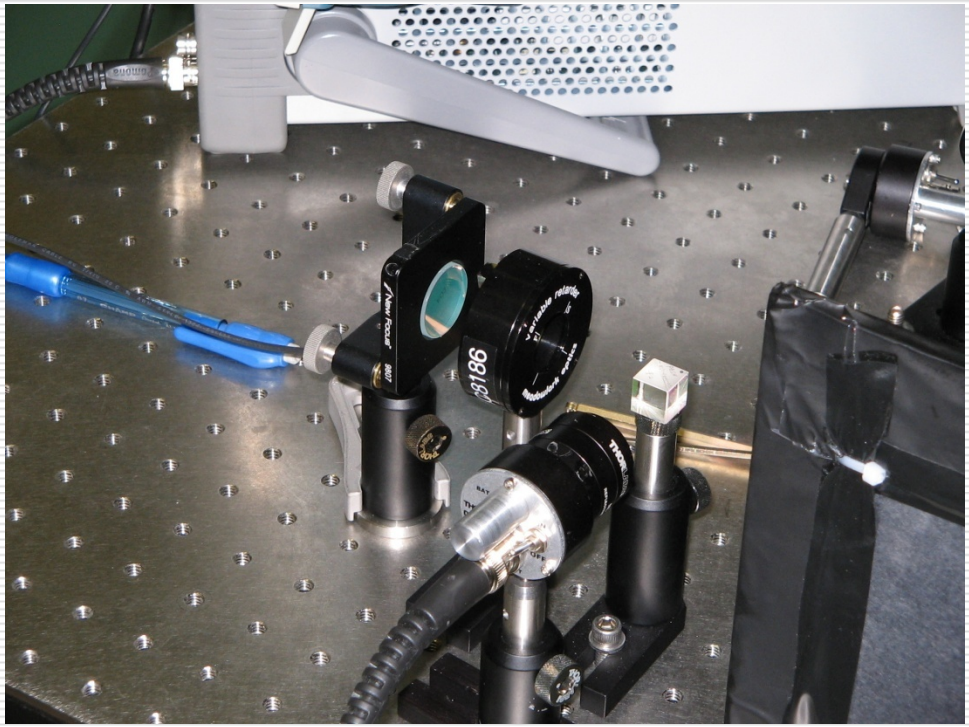


- Problem!

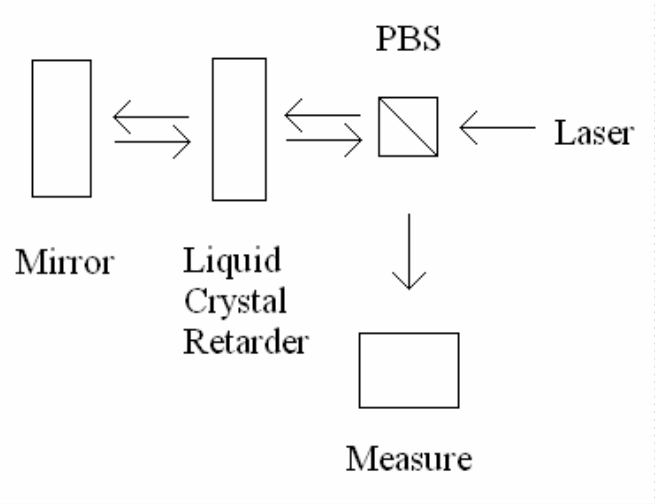
3. Experimental setup 2

- Setup





3. Experimental setup 2



- Calculation of Intensity
  - Retardance : $\Gamma = \frac{2\pi}{\lambda}(n_e - n_o)d$
  - Electric field : $E' = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} \cos(\Gamma/2) & -i\sin(\Gamma/2) \\ -i\sin(\Gamma/2) & \cos(\Gamma/2) \end{pmatrix} \begin{pmatrix} \cos(\Gamma/2) & -i\sin(\Gamma/2) \\ -i\sin(\Gamma/2) & \cos(\Gamma/2) \end{pmatrix} E_0 \begin{pmatrix} 0 \\ 1 \end{pmatrix}$
  - Intensity : $I = I_0 \sin^2(\Gamma)$

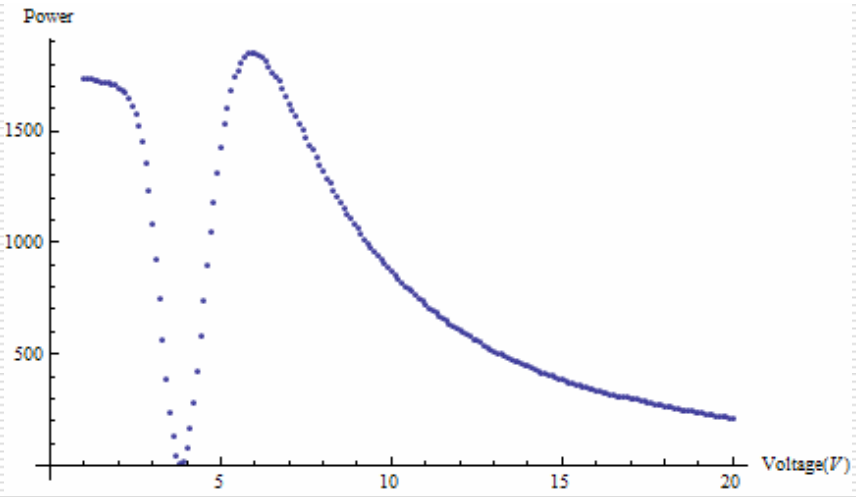
3. Experimental setup 2

- Intensity

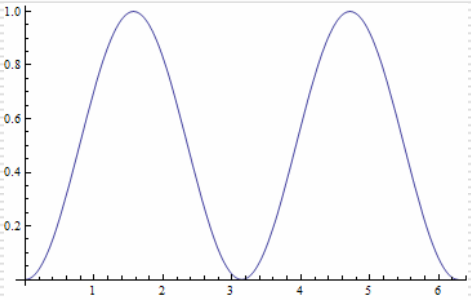
$$I = I_0 \sin^2(\Gamma)$$

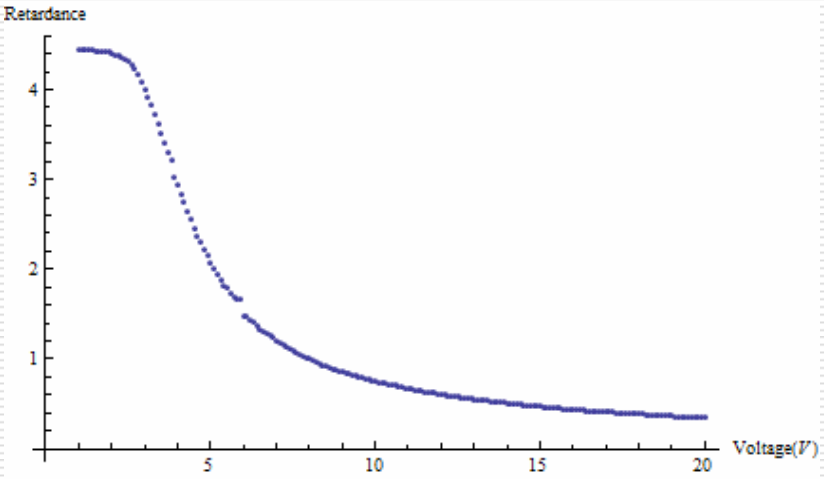
- Retardance

$$\Gamma = \sin^{-1}\left(\sqrt{\frac{I}{I_0}}\right)$$



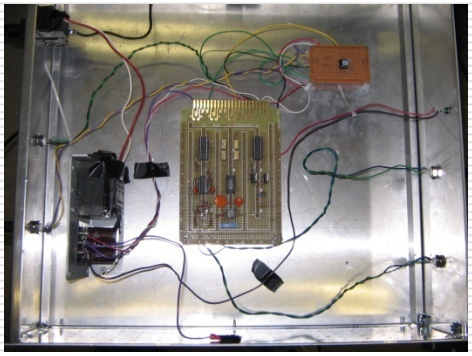
$\sin^2(x)$

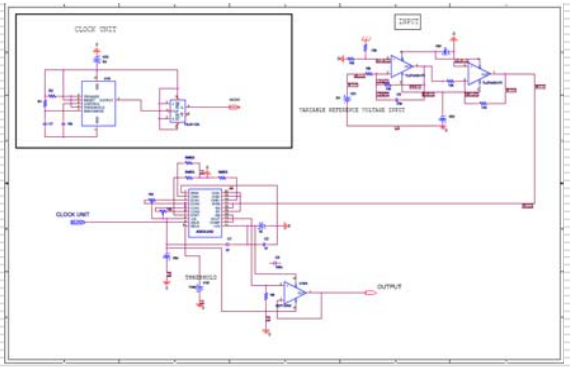




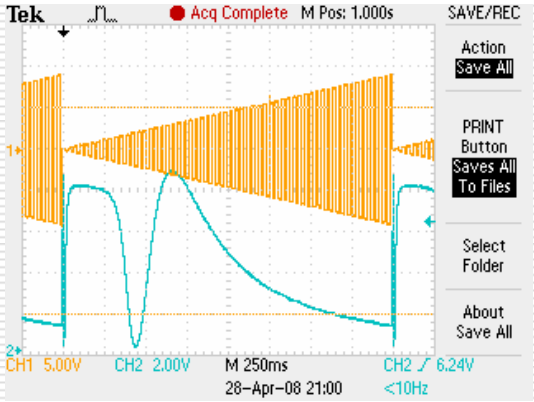
3. Experimental setup 2

- Development of electrical circuits by Bartosz Bogucki (Thanks a lot!)
  - Automatic control of oscillating square curve



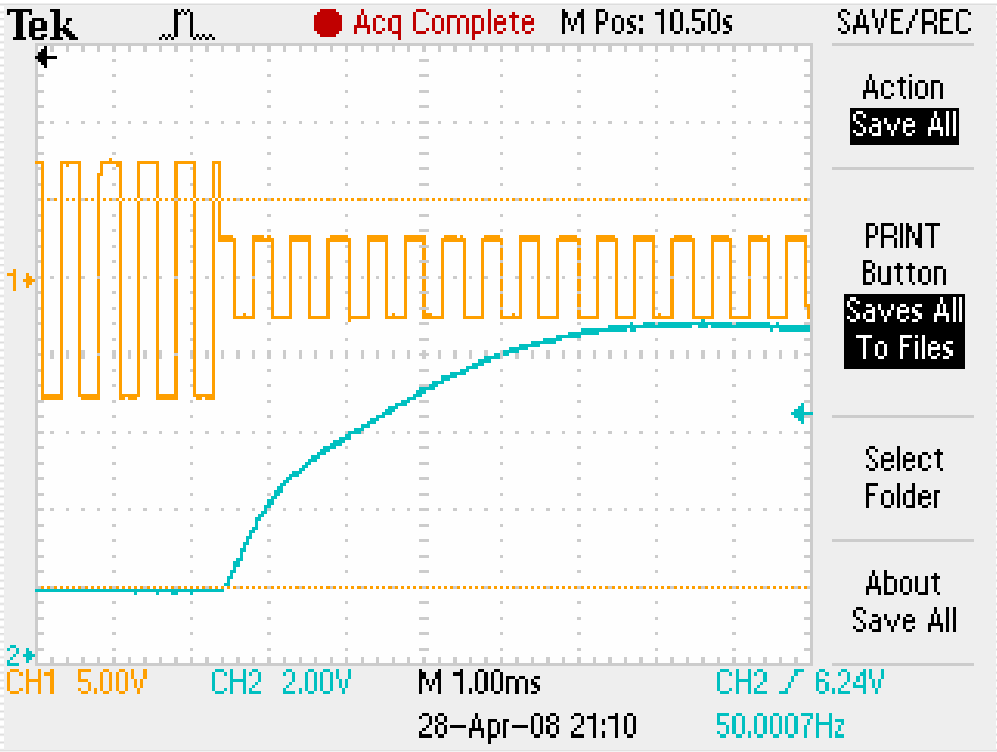


- Oscilloscope curve



3. Experimental setup 2

- Measurement of response time



References

1. A. Yariv, P Yeh, Photonics, Oxford University Press, 2007
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3. Manual – Retarder, Meadowlark Optics
4. P. Horowitz, W. Hill, The Art of Electronics, Cambridge University Press, 1989
5. C. J. Pethick, H. Smith, Bose-Einstein Condensation in Dilute Gases, Cambridge University Press, 2002

Thanks to Bartosz Bogucki and Dominik Schneble!