Assignment 7

1. Mica is commonly used for waveplates. Its indices of refraction for extraordinary and ordinary rays are 1.599 and 1.594 for yellow light. What is the minimum thickness of mica for
   a) λ/2 plate
   b) λ/4 plate

$$\Delta\phi = \frac{(n_o - n_e)\, d\, 2\pi}{\lambda}.$$

$$\therefore d = \frac{\lambda}{2\pi} \frac{\Delta\phi}{n_o - n_e}.$$

Half Wave Plate: $\Delta\phi = \pi$

$$\Rightarrow d = \frac{6\times10^{-7} \times \pi}{2\pi \times (1.599 - 1.594)}$$

$$= 6\times10^{-5}\ m$$

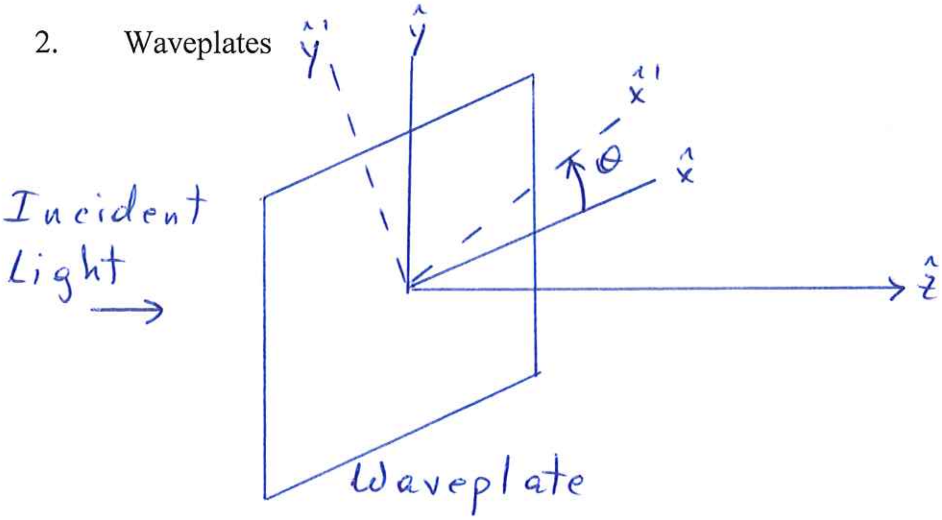
$$= 60\ \mu m$$

Quarter Wave Plate: $\Delta\phi = \frac{\pi}{2}$

$$\Rightarrow d = 30\ \mu m$$

Note that the thickness depends on λ. Hence, if a waveplate is purchased for one wavelength, it won't work the same way at another wavelength.

2. Waveplates



For $\theta = 45°$

$$\hat{x}' = \frac{1}{\sqrt{2}}(\hat{x} + \hat{y}) \quad \text{OR} \quad \hat{x} = \frac{1}{\sqrt{2}}(\hat{x}' - \hat{y}')$$

$$\hat{y}' = \frac{1}{\sqrt{2}}(-\hat{x} + \hat{y}) \qquad \hat{y} = \frac{1}{\sqrt{2}}(\hat{x}' + \hat{y}')$$

a) L.P. Incident light $\vec{E}_{inc} = E_0 \hat{y}$

$$= \frac{E_0}{\sqrt{2}}(\hat{x}' + \hat{y}')$$

$$\therefore \vec{E}_{after\ \lambda/2} = \frac{E_0}{\sqrt{2}}(\hat{x}' + \hat{y}' e^{i\pi})$$

$$= \frac{E_0}{\sqrt{2}}(\hat{x}' - \hat{y}')$$

$= E_0 \hat{x}$ L.P. along $\hat{x}$ axis (i.e. pol. axis rotated by 90°)

b) C.P. Incident light $\vec{E}_{inc} = \frac{E_0}{\sqrt{2}}(\hat{x} + i\hat{y})$

$$\therefore \vec{E}_{after\ \lambda/4} = \frac{E_0}{\sqrt{2}}(\hat{x}' + i\hat{y}' e^{i\pi/2})$$

$$\propto \frac{E_0}{\sqrt{2}}(\hat{x}' - \hat{y}')$$

$\propto E_0 \hat{x}$ L.P. along $\hat{x}$ axis.

3. What voltage is required to rotate linearly polarized light by 90° if green light passes through a KDP Pockels Cell?

Voltage $V = \dfrac{\lambda}{2 n_o^3 r}$

$= \dfrac{5.5 \times 10^{-7}\ m}{2 (1.51)^3 \times 10.6 \times 10^{-12}\ m/N}$

$\simeq 7500\ V.$

$\therefore V = 7.5\ kV$

Note: This can be a lethal voltage and caution is therefore required around pulsed lasers having a Pockels Cell

4. Calculate the magnetic field needed to use the Faraday Effect to rotate the axis of linear polarized light 90° when it passes through 1 cm of quartz. How does this compare to the Earth's magnetic field?

Field $B = \dfrac{\theta}{V d}.$

$= \dfrac{90^\circ}{.0166 \text{ arc min/gauss/cm} \times 1\text{ cm}}$

$= \dfrac{90}{.0166 \times \frac{1}{60}}$

$B = 325{,}000$ Gauss

$B_{Earth} \simeq 0.5$ Gauss is miniscule in comparison.

5. Acousto/Electro-Optic Modulators

a) What are the differences in the light produced by acousto and electro-optic modulators?

1) AO modulators typically operate at lower frequencies $\lesssim 1$ GHz

2) AO produces beams at various freqs. that are spatially separated

3) AO modulation frequencies more widely tunable eg. $\nu_{mod} = 300 \pm 150$ MHz where as for EO tunability is about 1% ν_{mod}

b) When would one modulator be more useful?

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