In class Example

Use the crystal ZnO

What is the direction of the applied electric field that results in no cross-terms?

$$\eta_4 = \eta_5 = \eta_6$$

The crystal Group is Hexagonal 6mm

Look at table 14.5

The r-matrix is $\begin{bmatrix} 0 & 0 & r_{13} \\ 0 & 0 & r_{13} \\ 0 & 0 & r_{33} \\ 0 & r_{51} & 0 \\ r_{51} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$

So $E = E_z$

What is the new index ellipsoid equation

$$\begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \end{bmatrix} = \begin{bmatrix} 0 & 0 & r_{13} \\ 0 & 0 & r_{13} \\ 0 & 0 & r_{33} \\ 0 & r_{51} & 0 \\ r_{51} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ E_z \end{bmatrix}$$

$\eta_1 = r_{13} E_z$

$\eta_2 = r_{13} E_z$ $\qquad \eta_4 = \eta_5 = \eta_6 = 0$

$\eta_3 = r_{33} E_z$

$$\left(\frac{1}{n_o^2} + r_{13} E_z\right) x^2 + \left(\frac{1}{n_o^2} + r_{13} E_z\right) y^2 + \left(\frac{1}{n_E^2} + r_{33} E_z\right) z^2 = 1$$

$$\frac{1}{n_o^2}\left(1 + n_o^2 \, r_{13} E_z\right) = \frac{1}{(n_x')^2}$$

$$n_x' = n_o \left(1 + n_o^2 \, r_{13} E_z\right)^{-1/2}$$

$$n_x' = n_o\left(1 - \tfrac{1}{2} n_o^2 r_{13} E_z\right) = n_o - \tfrac{1}{2} n_o^3 r_{13} E_z$$

$$n_x' = n_o - \tfrac{1}{2} n_o^3 r_{13} E_z$$
$$n_y' = n_o - \tfrac{1}{2} n_o^3 r_{13} E_z$$
$$n_z = n_E - \tfrac{1}{2} n_E^3 r_{33} E_z$$

In order to have birefringence what are the chosen polarization directions?

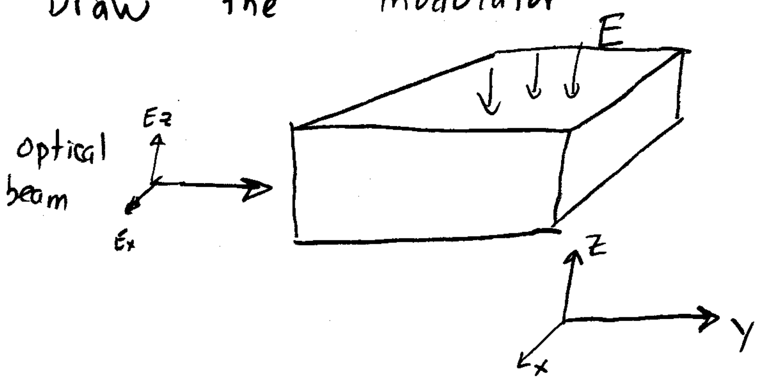
What is the resulting propagation direction?

$n_x' = n_y'$ so

x-y plane and z

$\hat{k} = \hat{y}$

Draw the modulator



What is the resulting birefringence?

$$B = n_z - n_x = n_E - \tfrac{1}{2} n_E^3 r_{33} E_z - n_o + \tfrac{1}{2} n_o^3 r_{13} E_z$$
$$= (n_E - n_o) + \tfrac{1}{2} E_z \left(n_o^3 r_{13} - n_E^3 r_{33} \right)$$