In class Example

Use the crystal ZnO.

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

\[ m_4 = m_5 = m_6 \]

The crystal group is Hexagonal 6mm.

Look at table 14.5.

The \( r \)-matrix is

\[
\begin{pmatrix}
0 & 0 & r_{13} \\
0 & 0 & r_{13} \\
r_{33} & 0 & 0 \\
r_{31} & 0 & 0 \\
r_{31} & 0 & 0 \\
0 & 0 & 0
\end{pmatrix}
\]

So \( E = E_2 \)

What is the new index ellipsoid equation

\[
\begin{pmatrix}
m_1 \\
m_2 \\
m_3 \\
m_4 \\
m_5 \\
m_6
\end{pmatrix} = \begin{pmatrix}
0 & 0 & r_{13} \\
0 & 0 & r_{13} \\
r_{33} & 0 & 0 \\
r_{31} & 0 & 0 \\
r_{31} & 0 & 0 \\
0 & 0 & 0
\end{pmatrix} \begin{pmatrix}
0 \\
E_2
\end{pmatrix}
\]

\[ m_1 = r_{13} E_2 \quad m_4 = m_5 = m_6 = 0 \]

\[ m_2 = r_{13} E_2 \]

\[ m_3 = r_{33} E_2 \]

\[
\left( \frac{1}{n_0^2} + r_{13} E_2 \right) x^2 + \left( \frac{1}{n_0^2} + r_{13} E_2 \right) y^2 + \left( \frac{1}{n_0^2} + r_{33} E_2 \right) z^2 = 1
\]

\[
\frac{1}{n_0^2} \left( 1 + n_0^2 r_{13} E_2 \right) = \frac{1}{(n_x')^2}
\]

\[ n_x' = n_0 \left( 1 + n_0^2 r_{13} E_2 \right)^{-\frac{1}{2}} \]

\[ n_x' = n_0 \left( 1 - \frac{1}{2} n_0^2 r_{13} E_2 \right) = n_0 - \frac{1}{2} n_0^3 r_{13} E_2 \]
\[ n_x' = n_0 - \frac{1}{2} n_0^3 r_{13} E_2 \]
\[ n_y' = n_0 - \frac{1}{2} n_0^3 r_{13} E_2 \]
\[ n_z = n_E - \frac{1}{2} n_E^3 r_{33} E_2 \]

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

What is the resulting propagation direction?

\[ n_x' = n_y' \text{ so} \]
\[ x-y \text{ plane and } z \]
\[ \hat{z} = \hat{y} \]

Draw the modulator

What is the resulting birefringence?

\[ B = n_z - n_x = n_E - \frac{1}{2} n_E^3 r_{33} E_2 - n_0 + \frac{1}{2} n_0^3 r_{13} E_2 \]
\[ = (n_E - n_0) + \frac{1}{2} E_2 \left( n_0^3 r_{13} - n_E^3 r_{33} \right) \]