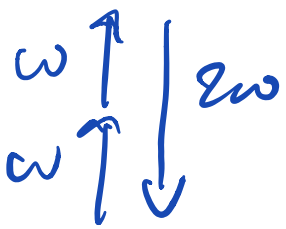
Quasi phase Matching

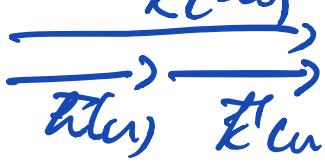
Issues with phase Matching condition.

Case SHG



$\Delta \vec{k} = \vec{k}'(2\omega) - 2\vec{k}'(\omega)$

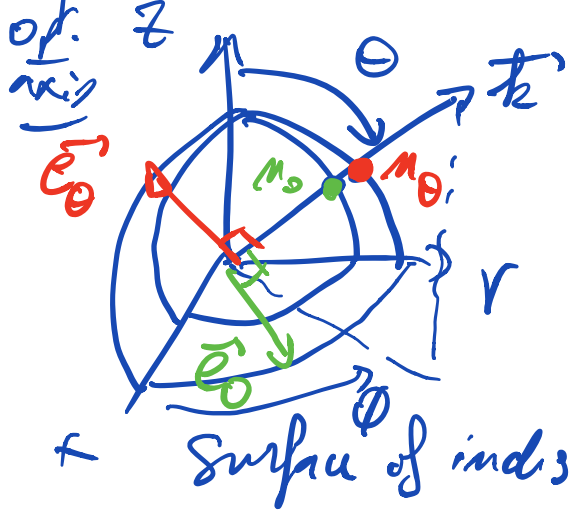
Colinear interaction



$\Rightarrow n(2\omega) = n(\omega)$ IMPOSSIBLE

1) Birefringence Prop of materials

Uniaxial crystal



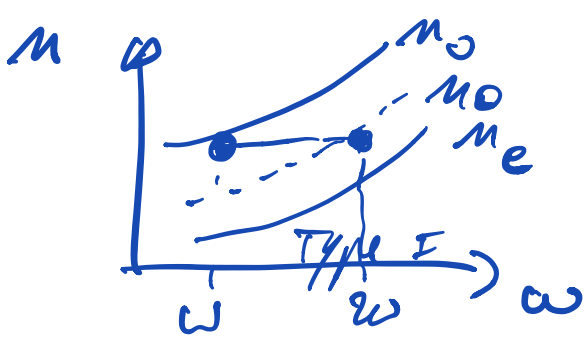
↑ Surface of inds.

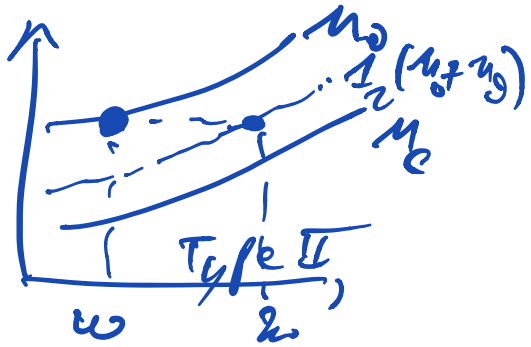
for 1 direction, light experiences 2 indices

n_o = ord.

n_θ = extra.

$\equiv \theta = \pi/2 \Rightarrow n_\theta = n_e$





$n_o(\omega) = n_\theta(2\omega)$

$n_\theta(\omega) = \frac{1}{2}\left(n_o(2\omega) + n_\theta(\omega)\right)$

$\Downarrow$

variation of θ enables to find $n_o(\omega) = n_\theta(2\omega)$

$\Rightarrow$ For some crystals, we are not able to find a solution !!

$\Rightarrow$ phase matching using Birefringence is sometimes IMPOSSIBLE

Issue related to some crystals where we intend to exploit the very high coef $\chi^{(2)}_{zzz}$

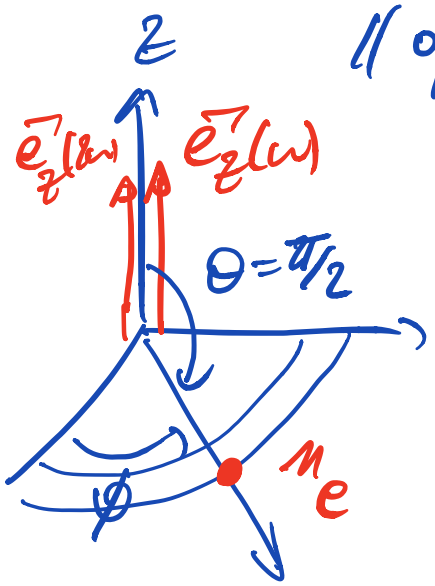
Ex: $LiNbO_3$ $\quad \chi^{(2)}_{zzz} \gg \chi^{(2)}_{ijk}$

$\chi^{(2)}_{zzz} = -60\ pm/V$

↳ Pb Issue: The phase matching is IMPOSSIBLE to fulfill...

$$\chi^{(2)}_{eff} = \vec{e}_z(2\omega)\, \chi^{(2)}_{zzz}(2\omega, \omega, \omega)\, e_z\, e_z(\omega)$$

↳ implication: The waves @ ω and 2ω are polarized // z // optical axis.



$$\Rightarrow \boxed{n_e(\omega) \neq n_e(2\omega)}$$

SOLUTION: quasi-plane wave solution

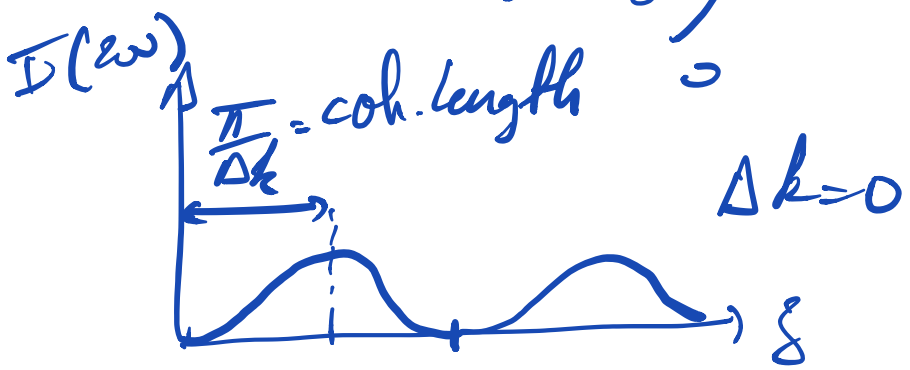
$$\frac{\partial A(2\omega)}{\partial \zeta} = \frac{i 2\omega}{2nc\varepsilon_0} \vec{e}_z \cdot \vec{P}_{NL}(2\omega) e^{-i k(2\omega)\zeta}$$

$$\vec{P}_{NL}(2\omega) = \vec{\pi}_{NL}(2\omega) e^{i 2\vec{k}(\omega)\zeta}$$

with $\vec{\pi}_{NL}(2\omega) = \chi^{(2)}_{zzz} \vec{e}_z \vec{e}_z A^2(\omega)$

$$\Rightarrow \boxed{\frac{\partial A(2\omega)}{\partial \zeta} = \frac{i 2\omega}{2nc\varepsilon_0} \vec{e}_z \cdot \vec{\pi}_{NL}(2\omega) e^{i\Delta k \zeta}}$$

$$\Rightarrow A(2\omega, L) = \frac{i 2\omega}{2nc\varepsilon_0} \int_0^L \vec{e}_z \cdot \vec{\pi}_{NL}(2\omega) e^{i\Delta k \zeta} d\zeta$$

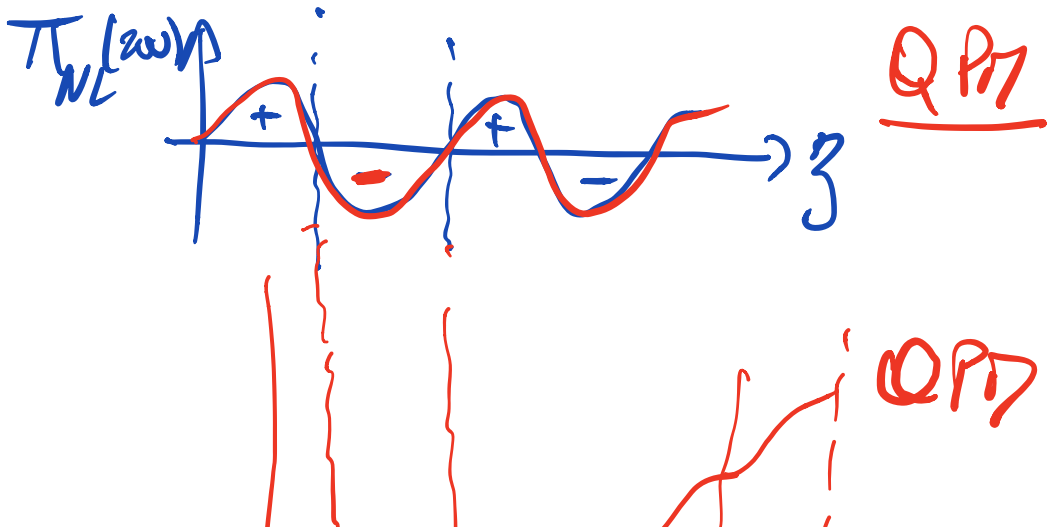


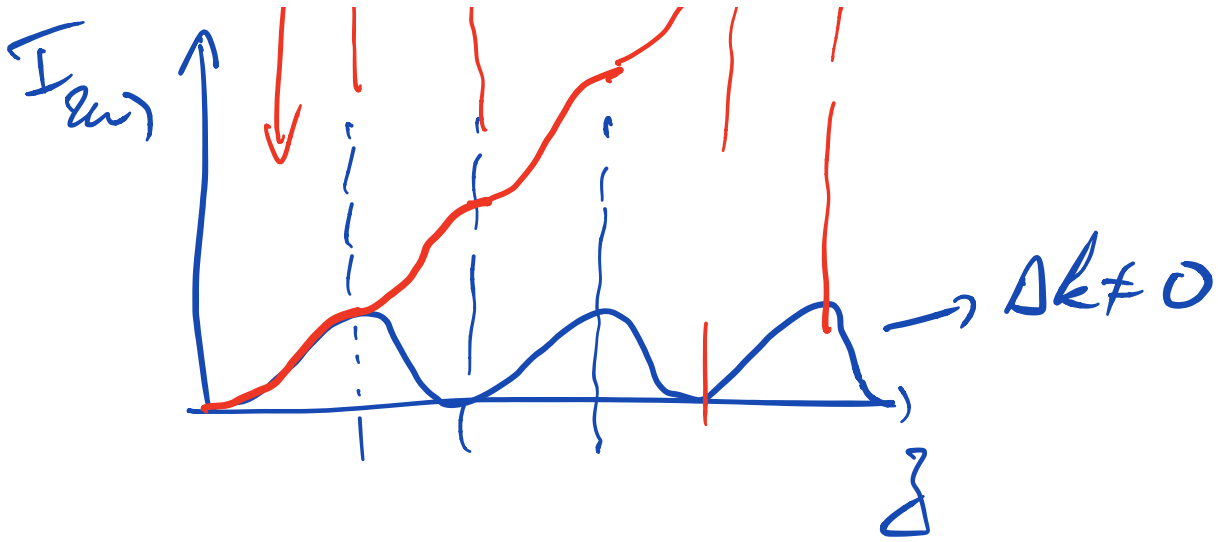
Solution: $\vec{\Pi}_{NL}(2\omega, z) = \vec{\Pi}_{NL}(z)\cos(kz)$

$$\Rightarrow A(2\omega, L) \propto \int \vec{e}_z \cdot \vec{\Pi}_{NL}(2\omega)\, \frac{e^{ikz} + e^{-ikz}}{2} \times e^{i\Delta k z}\, dz$$

$\Rightarrow$ For $\boxed{\vec{K} = \Delta\vec{k}}$ the phase matching condition can be fulfilled

IMPLICATION:




I_{eff}
$\Delta k \neq 0$
δ