Spatial effects

- crossed beams
- walkoff
- Focusing
- waveguides.

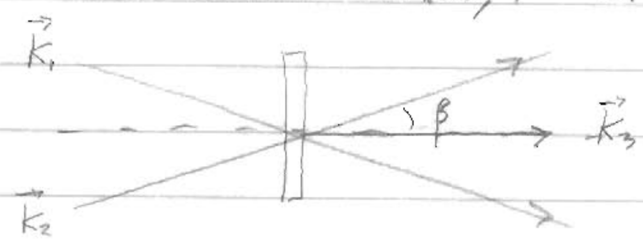
1) crossed beams: plane waves

$$\vec{E}_1 = A_1 e^{i\vec{k}_1\cdot\vec{r}}, \text{ etc.}$$

$$A_3' \propto A_1 A_2 e^{i\Delta\vec{k}\cdot\vec{r}}$$

$$\Delta\vec{k} = \vec{k}_1 + \vec{k}_2 - \vec{k}_3$$

non-collinear mixing: $\omega_1 = \omega_2$



$$P_{NL} \propto \chi^{(2)} E^2 \propto A_1^2 e^{2i\vec{k}_1\cdot\vec{r}} + A_2^2 e^{2i\vec{k}_2\cdot\vec{r}} + A_1 A_2 e^{i(\vec{k}_1+\vec{k}_2)\cdot\vec{r}} + c.c \quad \Big\} 2\omega_1$$

$$+ A_1 A_2^* e^{i(\vec{k}_1-\vec{k}_2)\cdot\vec{r}} + c.c \quad (D.C.)$$

write eqn for each output wave, direction

sum mixing:

$$\frac{\omega_1}{c} n_1 \cos\beta\, \hat{z} - \frac{\omega_1}{c} n_1 \sin\beta\, \hat{x}$$

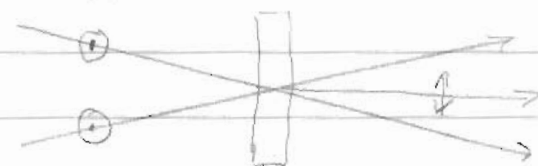
$$+ \frac{\omega_1}{c} n_1 \cos\beta\, \hat{z} + \frac{\omega_1}{c} n_1 \sin\beta\, \hat{x}$$

$$\frac{2\omega_1}{c} n_1 \cos\beta\, \hat{z} \quad \rightarrow \text{wave in } \hat{z} \text{ direction}$$

$$\Delta k = \frac{2\omega_1}{c} n_1 \cos\beta - \frac{\omega_2}{c} n_2 = 0 \rightarrow n_1 \cos\beta = n_2$$

crossing angle lowers effective index
- changes phase matching angle.

two options for type I

1) 

$\vec{E}_1, \vec{E}_2 \parallel \hat{y}$
and along n_o

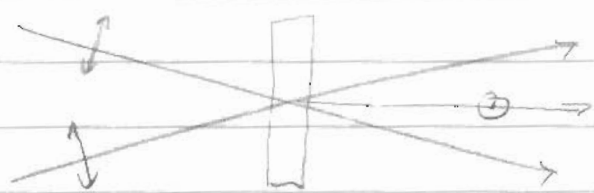
normal tuning angle is around $\hat{y}$

n_1 is still $= n_o(\omega_1)$

optimum crystal angle is set for

$$n_o(\omega_1)\cos\beta = n_e(\omega_2, \theta)$$

In doubling directions, SH is not phase-matched.

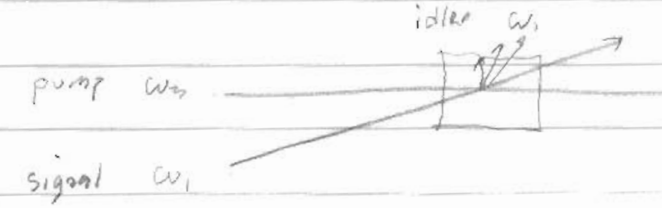
2) 

here, the input polarization has a projection on both n_o and $n_e(\theta)$ axes

- only n_o part will be phase matched

∴ use version 1.

NOPA: non-collinear OPA



idler can come out over a range of directions

→ $\Delta k = 0$ over a wide spectral range.

shortest pulses.