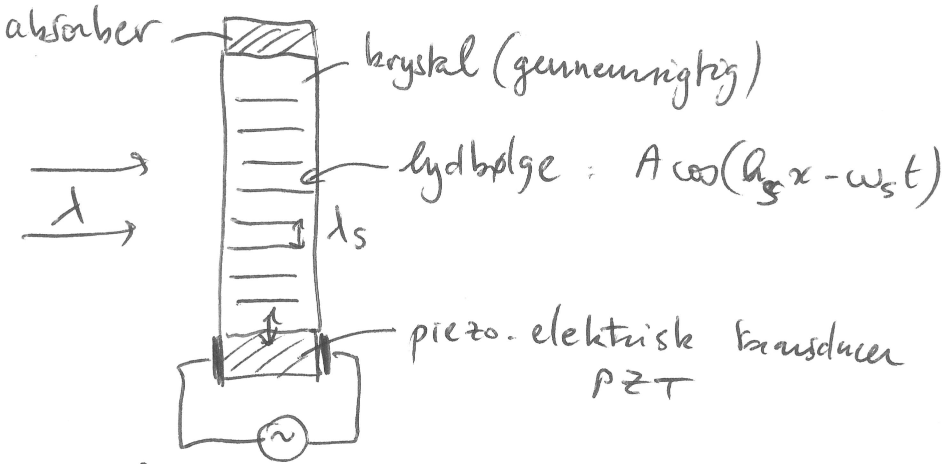
Akusto-optisk modulator/deflektor (AOM)



$$k_s = \frac{2\pi}{\lambda_s}$$

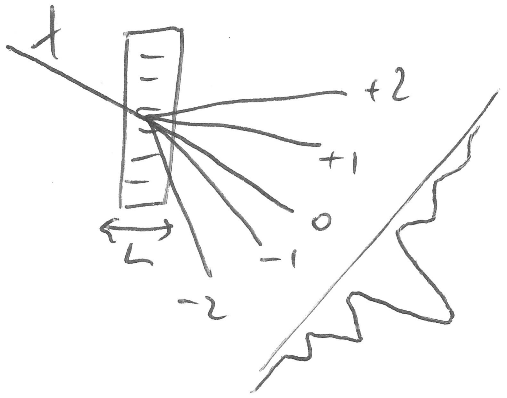
$$\lambda_s = \frac{v_s}{f_s}$$

f_s, rf MHz-GHz

elektrisk mod. i PZT → mek. vibrationer
→ lydbølge i krystal
→ mod. trækstyrke / tæthed
→ mod. brydningsindeks $n(x,t) = n + \Delta n \cos(k_s x - \omega$
→ mod. optisk stråles fase

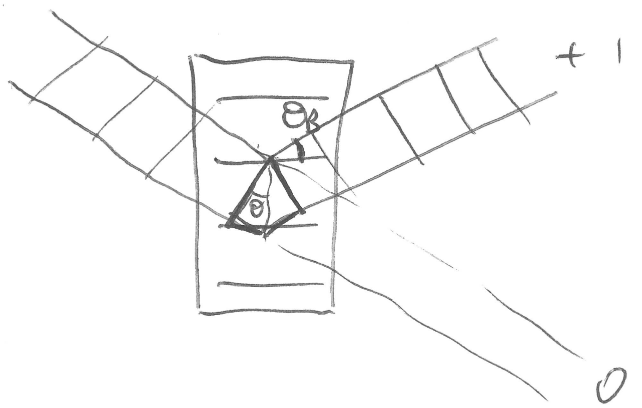
"foto-elastisk" effekt

Gitter: diffraktion af lysbølge



$$f_n = f \pm n f_s \qquad n = 0, \pm 1, \pm 2, \ldots$$

"Raman-Nath" regime $\quad Q = \dfrac{2\pi \lambda L}{n \lambda_s^2} \ll \quad$ (lav f_s, kort L)



Bragg betingelse:

$$2k \sin\theta_B = k_S$$

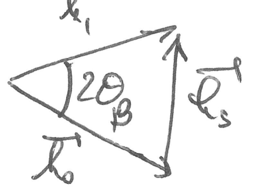
$$(k_1 \simeq k_0 \gg k_S)$$

Bragg regime $Q \gg 1$: kun en order

$$\sin\theta_B \simeq \theta_B = \frac{k_S}{2k} = \frac{\lambda f_S}{2 n v_S}$$

λ: bølgelængde i vakuum
n: brydningsindeks

$\Rightarrow$



$$\vec{k}_1 = \vec{k}_0 + \vec{k}_S$$

$$f_1 = f_0 + f_S$$

og $\boxed{\theta_{sep} = 2\theta_B = \frac{\lambda f_S}{n v_S}}$

[tolkes også som stød mellem foton og fonon, hvor både energi og impuls er bevaret, se senere ...]

- Anvendelser af AOM

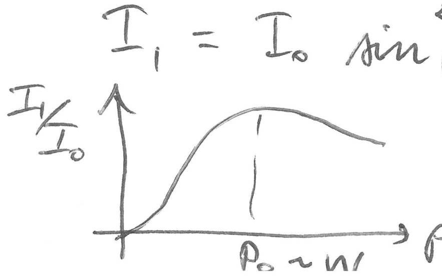
1) Deflektor (laser cutting, laser printing)

2) Amplitude modulation (video signal overførsel, noise eater, Q switch in lasers ...)

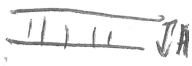
3) Frekvens shift (spektroskopi, frekvens filter, ...)

- Effektivitet

$$I_1 = I_0 \sin^2(\sqrt{\eta}) \quad \text{med} \quad \eta = \frac{\pi^2}{4}\frac{P}{P_0} \quad \text{hvor} \quad P_0 = \frac{\lambda^2}{2M_2}\frac{H}{L}$$

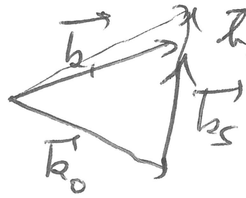


~~ex~~ H: "højde" af lydbølge



M_2: akusto-optisk koeff.

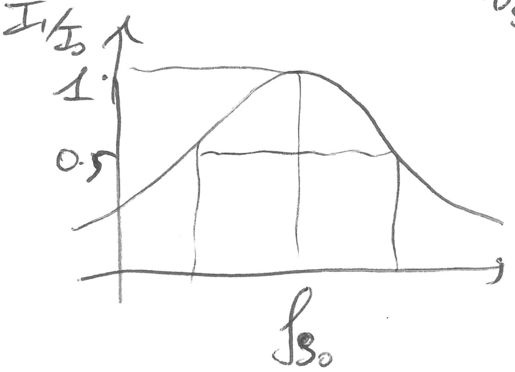
Båndbredde



$\vec{k}_1 + \Delta\vec{k}_s$: lavere diffraktions effektivitet

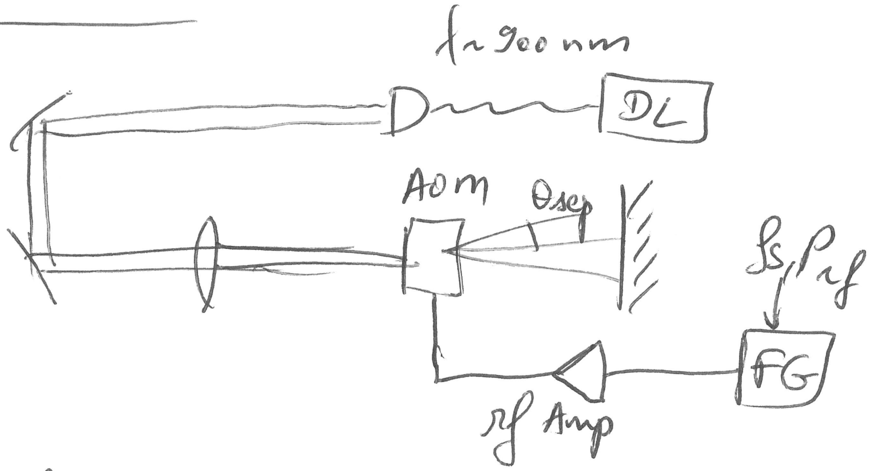
$$I_1/I_0 = \eta \, \mathrm{sinc}^2\left[\sqrt{\eta + \frac{\Delta\phi^2}{4}}\right]$$

hvor $\Delta\phi = \Delta k_s \cdot L = \frac{\pi\lambda}{v_s} \, \frac{f_s - f_{s_0}}{2} \, \frac{L}{\Lambda_{s_0}}$



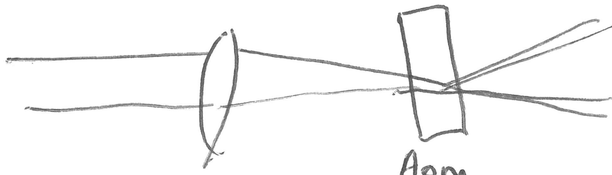
båndbredden øges ved at øge $\frac{\Lambda_s}{L}$

Prog. modul 1

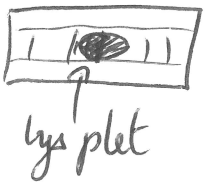


- se diffraktions pletter, optimere effektivitet i fx +1/-1 orde[n]
- varier P_{rf}, f_s
- mål θ_{sep} for $\div f_s$, deducér v_s (usikkerhed?)
- mål $I_1/I_0 = f(P_{rf})$, $f(f_s)$, båndbredde?

• Hastighed for at tænde/slukke for lyset ?

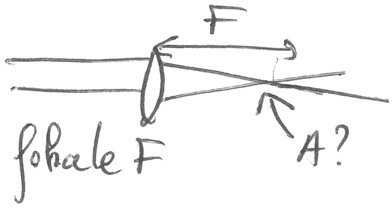


Aom



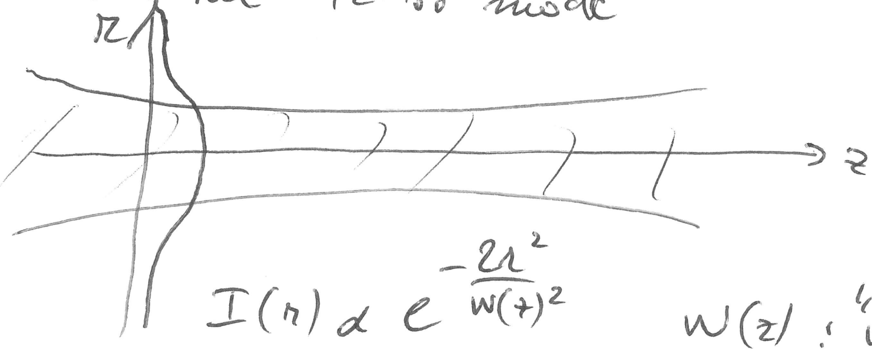
$$T_R \propto \frac{A}{v_s}$$

• Geometrisk optik



⇒ Gaussiske stråle (Gaussiske modefunktioner fra løsning af Maxwells ligningen i paraksial approks.)

For fundamental TEM_{00} mode

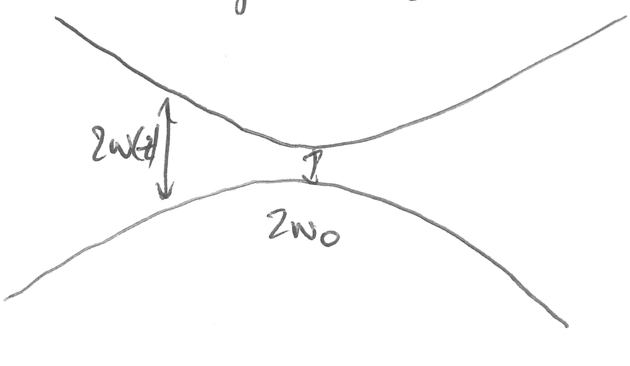


$$I(r) \propto e^{-\frac{2r^2}{w(z)^2}}$$

$w(z)$: "waist"

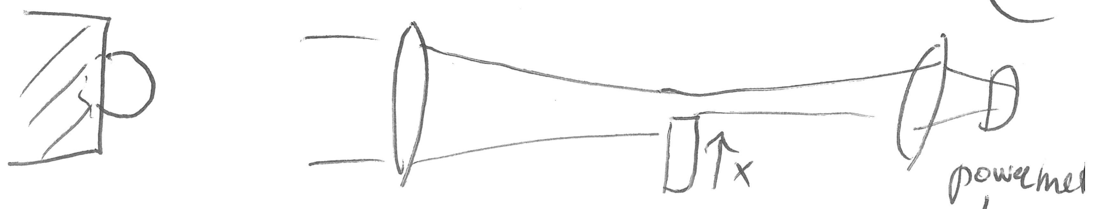
$2w(z)$ "spotsize"

Fokus fra linse:



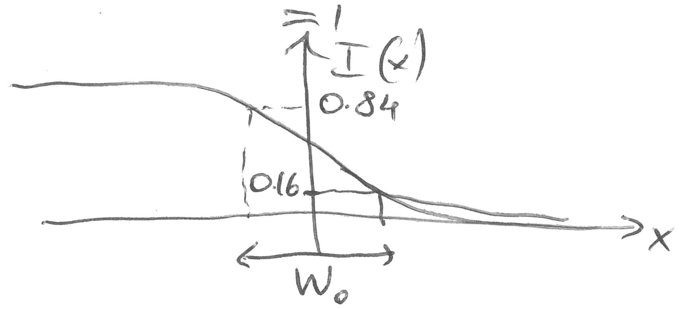
$$\boxed{w_0 = \frac{\lambda F}{\pi w_0'}}$$

∘ Måling w_0?



$$I = \frac{2}{\pi w_0^2}\int_{-\infty}^{+\infty} e^{-\frac{2(x^2+y^2)}{w_0^2}}\,dx\,dy \qquad \text{(norm. intensitet)}$$

$$I(x) = \underbrace{\left(\sqrt{\frac{2}{\pi w_0^2}}\int_{-\infty}^{+\infty} e^{-\frac{2y^2}{w_0^2}}\,dy\right)}_{=1}\left(\sqrt{\frac{2}{\pi w_0^2}}\int_{-\infty}^{x} e^{-\frac{2x'^2}{w_0^2}}\,dx'\right) = \mathrm{erf}\left(\frac{x\sqrt{2}}{w_0}\right)$$



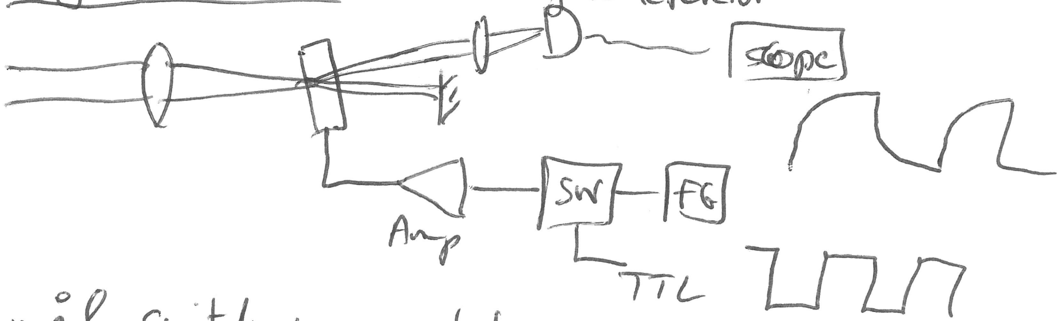
∘ Risetime? $x = v_s t$

Per definition T_R = tid for at gå fra 10% til 90% af I

$$T_R = t_{90\%} - t_{10\%} = \frac{1}{v_s}\left(x_{90\%} - x_{10\%}\right) = \frac{w_0}{v_s\sqrt{2}}\left[\mathrm{erf}^{-1}(0.9) - \mathrm{erf}^{-1}(0.1)\right]$$

$$\boxed{T_R = 0{,}64\,\frac{2w_0}{v_s}}$$

∘ Prog modul 2



- mål switch responsetid
- mål waist ved krystal
- mål T_R og find v_s
- gentag for ÷ waists