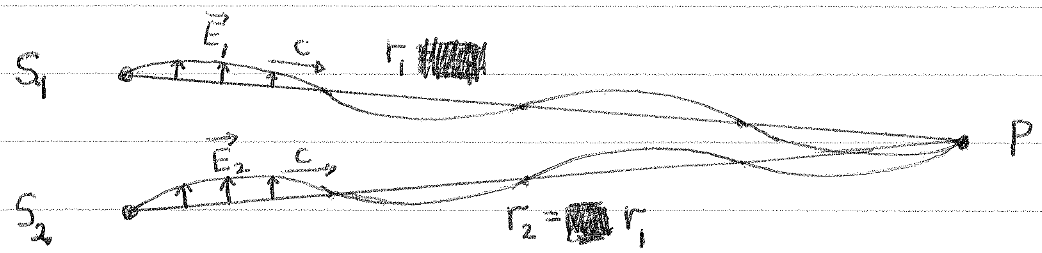
6.11.06

<u>Konstruktiv</u> interferens: (anta $\overbrace{\text{ }}^{\text{kildene}}$ S_1 og S_2 i fase)



$$\vec{E}_p = \vec{E}_{1p} + \vec{E}_{2p} = \vec{E}_{10} \cos(\vec{k}_1 \cdot \vec{r}_1 - \omega t) + \vec{E}_{20} \cos(\vec{k}_2 \cdot \vec{r}_2 - \omega t)$$

$\vec{k}_1 \cdot \vec{r}_1 \approx \vec{k}_2 \cdot \vec{r}_2$ hvis $r_1 = r_2$ og tilnærmet parallelle stråler ($\vec{k}_1 \approx \vec{k}_2$)
$= kr$

$$\Rightarrow \vec{E}_p = (\vec{E}_{10} + \vec{E}_{20}) \cos(\vec{k} \cdot \vec{r} - \omega t)$$

hvis også likt polarisert: $\vec{E}_{10} = \vec{E}_{20} = \vec{E}_0$
(og lik intensitet)

$$\Rightarrow \vec{E}_p = 2\vec{E}_0 \cos(kr - \omega t)$$

$$\Rightarrow I_p = c\varepsilon_0 \langle E_p^2 \rangle = 4c\varepsilon_0 E_0^2 \langle \cos^2(kr - \omega t) \rangle = 2c\varepsilon_0 E_0^2$$

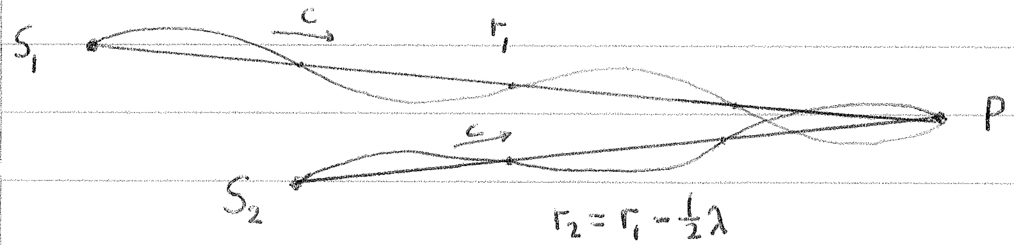
$I_1 = c\varepsilon_0 \langle E_{1p}^2 \rangle = \frac{1}{2} c\varepsilon_0 E_0^2$, $\quad I_2 = c\varepsilon_0 \langle E_{2p}^2 \rangle = \frac{1}{2} c\varepsilon_0 E_0^2$

$\Rightarrow I_p = 2(I_1 + I_2)$ "Konsentrasjon" av energien

Får samme resultat med $\boxed{r_2 = r_1 + n\lambda}$ $(n = 0, \pm 1, \pm 2, \ldots)$
fordi:

$$\cos(kr_2 - \omega t) = \cos(kr_1 + nk\lambda - \omega t) = \cos(kr_1 + n \cdot 2\pi - \omega t)$$
$$= \cos(kr_1 - \omega t)$$

<u>Destruktiv</u> interferens :



$$\vec{E}_P = \vec{E}_0 \cos(kr_1 - \omega t) + \vec{E}_0 \cos(kr_2 - \omega t)$$

$$= \vec{E}_0 \cos(kr_1 - \omega t) + \vec{E}_0 \cos(kr_1 - \omega t - \underbrace{\tfrac{1}{2}k\lambda}_{\pi})$$

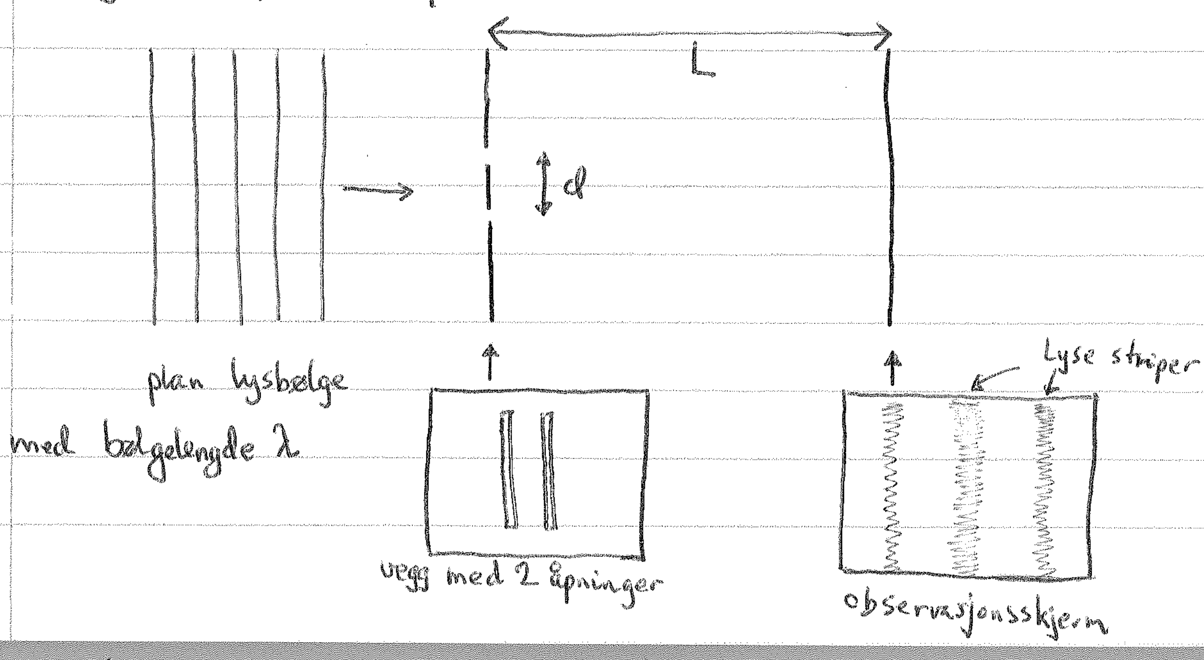
$$\boxed{\begin{array}{l}\cos(\alpha - \pi) \\ = -\cos\alpha\end{array}}$$

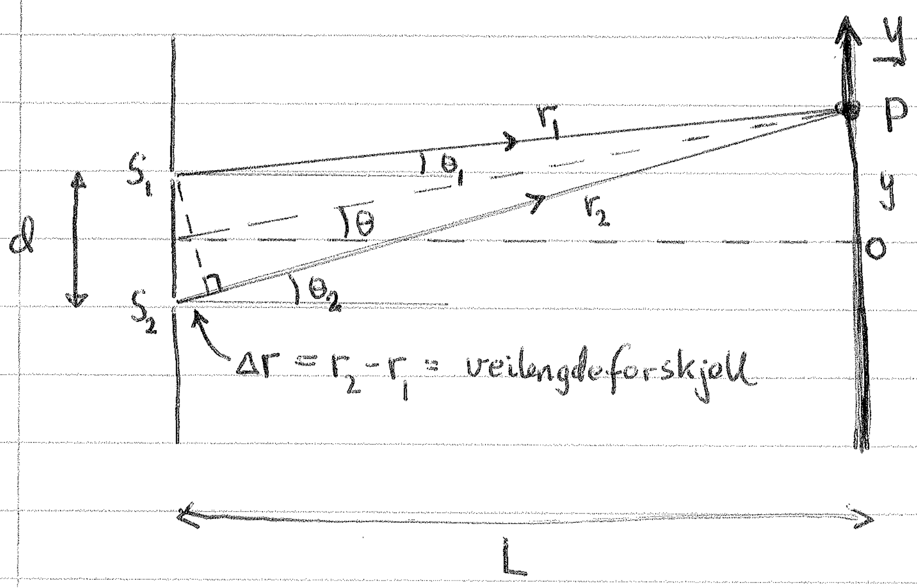
$$= (\vec{E}_0 - \vec{E}_0)\cos(kr_1 - \omega t) = 0$$

$$I_P = 0$$

Samme resultat med $\boxed{r_2 = r_1 - (n + 1/2)\lambda}$ $\quad (n = 0, \pm 1, \pm 2, \ldots)$

<u>Youngs tospalteeksperiment</u> (ca 1800) (LHL 30.2





Antagelser:

- $d \ll L \Rightarrow \theta_1 = \theta_2 = \theta$

$$\Delta r = r_2 - r_1 = d \sin\theta$$

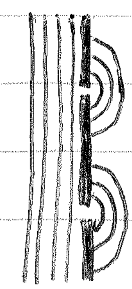
$\Rightarrow$ Konstruktiv interferens (lysmaksima) for

$$d \sin\theta_n = n\lambda \qquad n = 0, \pm 1, \pm 2, \ldots$$

Destruktiv interferens (lysminima) for

$$d \sin\theta_n = (n + \tfrac{1}{2})\lambda \qquad n = 0, \pm 1, \pm 2, \ldots$$

Har her antatt to lange, tynne spalter som – via Huygens' prinsipp – blir opphav til to sylinderbølger i fase:



Intensitetsfordelingen i tospalteeksperimentet (LHL 30.3

Elektrisk felt i P fra
bølge fra spalte i : $E_i = E_0 \sin(kr_i - \omega t)$; $i = 1,2$

Totalt felt i P : $E = E_1 + E_2 = E_0 \left\{ \sin(kr_1 - \omega t) + \sin(kr_2 - \omega t) \right\}$

$$\sin\alpha + \sin\beta = 2\cos\left(\frac{\alpha-\beta}{2}\right)\sin\left(\frac{\alpha+\beta}{2}\right)$$

$$\Rightarrow E = 2E_0 \cos\frac{k(r_2-r_1)}{2} \sin\left(\frac{k(r_2+r_1)}{2} - \omega t\right)$$

Merk: E_0 avtar med økende r for sylinderbølge, men antar samme E_0 i P fra begge spalter

$$I = c\varepsilon_0 \langle E^2 \rangle = c\varepsilon_0 \cdot 4E_0^2 \cos^2\left(\frac{kd\sin\theta}{2}\right) \underbrace{\left\langle \sin^2\left(\frac{k(r_2+r_1)}{2} - \omega t\right)\right\rangle}_{1/2}$$

$$= 2c\varepsilon_0 E_0^2 \cos^2\left(\frac{kd\sin\theta}{2}\right)$$

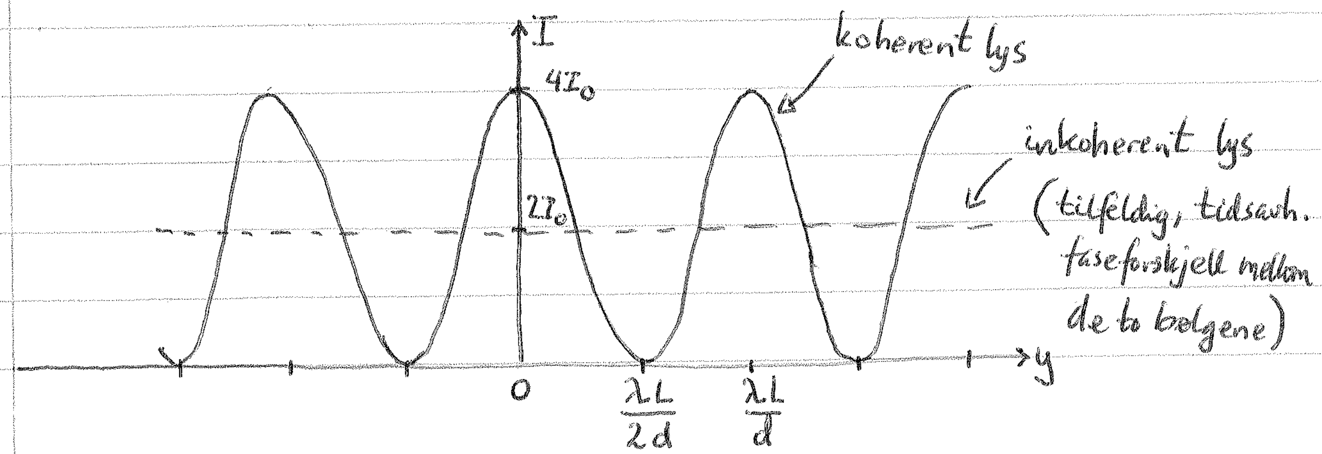
Hvis en spalte: $I_0 = c\varepsilon_0 E_0^2 \langle \sin^2(kr - \omega t) \rangle = \frac{1}{2} c\varepsilon_0 E_0^2$

$$\Rightarrow \boxed{I(\theta) = 4I_0 \cos^2\left(\frac{kd\sin\theta}{2}\right)}$$

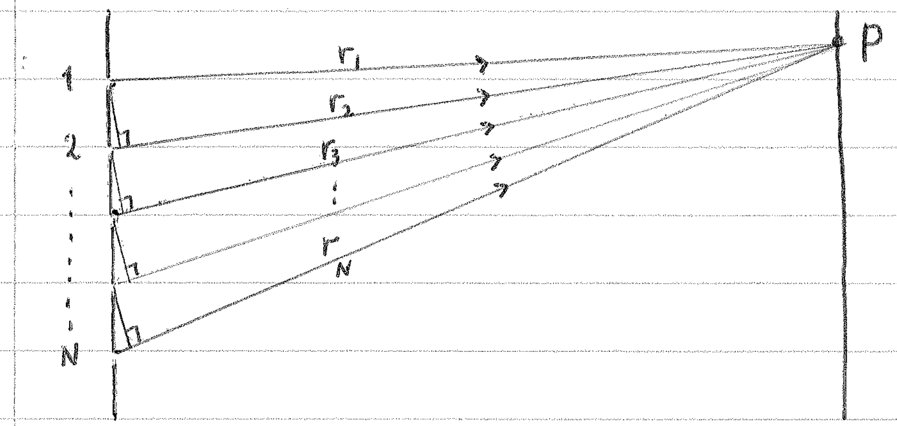
$\sin\theta \approx \tan\theta = y/L$ for små vinkler (dvs $y \ll L$)

$k = 2\pi/\lambda$

$$\Rightarrow \boxed{I(y) = 4I_0 \cos^2\left(\frac{\pi d y}{\lambda L}\right)}$$



Mange spalter: Diffraksjonsgitter (LHL 30.4



$(N=5)$ $$r_2 - r_1 \approx r_3 - r_2 \approx \ldots \approx r_N - r_{N-1} \approx d\sin\theta$$

små veilengdeforskjeller $\Rightarrow$ antar lik amplitude E_0 i P fra alle N spaltene

$$\Rightarrow E = E_1 + E_2 + \ldots + E_N$$

$$= E_0 \sin(kr_1 - \omega t) + E_0 \sin(kr_1 + kd\sin\theta - \omega t) + \ldots + E_0 \sin(kr_1 + (N-1)kd\sin\theta - \omega t)$$

$$= E_0 \sum_{j=0}^{N-1} \sin(kr_1 + j\,kd\sin\theta - \omega t) = E_0 \,\mathrm{Im} \sum_{j=0}^{N-1} e^{i(kr_1 + j\,kd\sin\theta - \omega t)}$$

$$= E_0 \frac{\sin\left(\frac{Nkd\sin\theta}{2}\right)}{\sin\left(\frac{kd\sin\theta}{2}\right)} \sin\left(kr_1 + \frac{(N-1)kd\sin\theta}{2} - \omega t\right)$$

$$\Rightarrow I = \underbrace{\frac{1}{2}E_0^2 c\varepsilon_0}_{I_0} \left\{\frac{\sin(Nkd\sin\theta/2)}{\sin(kd\sin\theta/2)}\right\}^2$$

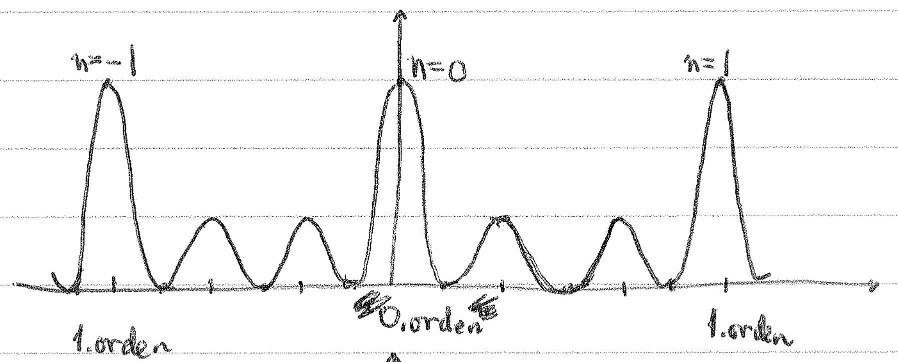
(fra en spalte)

Max I når $kd\sin\theta/2 = n\cdot\pi$; $n = 0, \pm 1, \pm 2, \ldots$

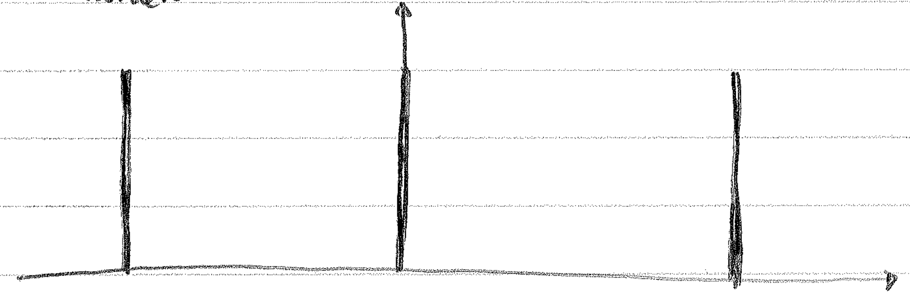
$$\Rightarrow \quad d\sin\theta = n\lambda$$

$\sin\alpha \approx \alpha$ for små α $\Rightarrow$ $\sin(Nkd\sin\theta/2)/\sin(kd\sin\theta/2) \overset{(\theta=0)}{\approx} N$

$\Rightarrow I = N^2 I_0$ når $d\sin\theta = n\lambda$



N=4

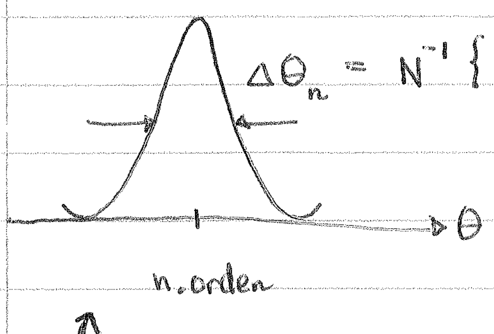


stor N

linjespektrum

Hit 6.11.06

N-1 nullpunkter og N-2 "lokale maksima" mellom to hovedmaksima



$$\Delta\theta_n = N^{-1}\left\{(d/\lambda)^2 - n^2\right\}^{-1/2}$$

Halvverdibredde

Bølgelengdeseparasjon: