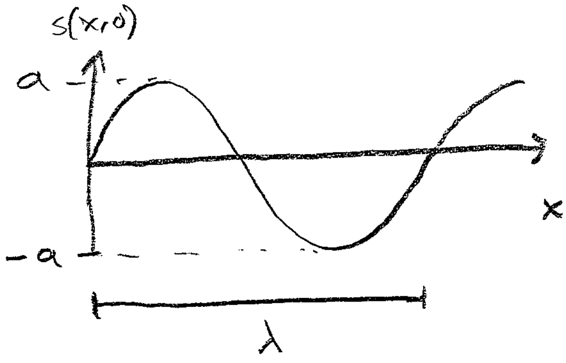
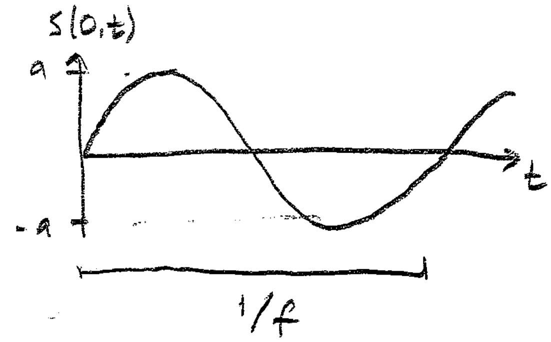
Övning 1. Aukustik   Formler

* Harmonisk våg

$$s(x,t) = a\sin(kx - \omega t)$$



$k = \frac{2\pi}{\lambda}$ vågtal $\left[\frac{rad}{m}\right]$



$\omega = 2\pi f$ vinkelfrekv. $\left[\frac{rad}{s}\right]$

a = amplitud $[m]$

* Effekt P

$$P = I \cdot A \qquad \left[W = \frac{J}{s}\right]$$

I är intensiteten och A är arean

* Intensitet

För en ljudvåg:

$$I = \frac{1}{2} a^2 \omega^2 Z = \frac{p_{max}^2}{2Z}$$

p: tryckamplituden $\left[Pa = \frac{N}{m^2}\right]$

$Z = \rho v$: aukustisk impedens $\left[\frac{kg}{m^2 s}\right]$ $\quad Z_{luft} \approx 420 \frac{kg}{m^2 s}$

$Z_{vatten} \approx 1.5 \cdot 10^6 \frac{kg}{m^2 s}$

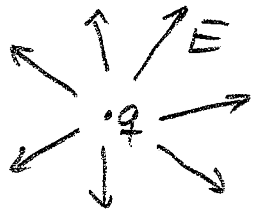
* Ljudintensitetsnivå

$$\beta = \log_{10}\left(\frac{I}{I_0}\right) \cdot 10\ dB \leftrightarrow I = I_0 10^{\beta/10\,dB}, \quad I_0 = 10^{-12} \frac{W}{m^2}$$

Övning 2. Elektrostatik, formler

- Elektriskt fält, E $[N/C = V/m]$

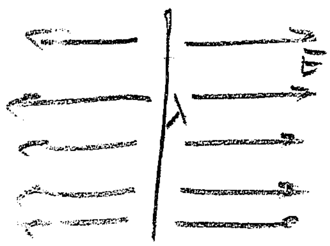
  - punktladdning q $[C]$



$$E = \frac{q}{4\pi\varepsilon_0 r^2}$$

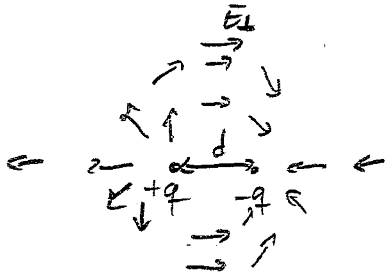
där $\varepsilon_0 = 8.85 \cdot 10^{-12} \frac{C}{Nm^2}$ är den elektriska konstanten

  - linjeladdning λ $[C/m]$



$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

  - elektrisk dipol



$$E_\perp = \frac{P}{4\pi\varepsilon_0 r^3},$$

$\bar{p} = q \cdot \bar{d}$ $[Cm]$: Dipolmoment

- Elektrisk kraft

$$\bar{F} = q\bar{E} \quad [N]$$

- Gauss sats

$$\oiint_S \bar{E} \cdot d\bar{S} = \frac{Q}{\varepsilon_0}$$

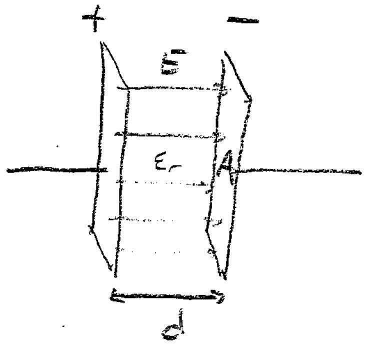
, Q är totala laddningen innesluten av ytan S

- Spänning U_{ab} över ett område mellan a och b

$$U_{ab} = \int_a^b \bar{E} \cdot d\bar{r} \quad [V]$$

Övning 3. Kondensatorer. Formler

Kondensator



Lagror en laddning Q och energi W när en spänning U läggs över den.

Kapacitans : $C = \frac{Q}{U}$ [F]

Energi : $W = \frac{1}{2} C U^2 = \frac{QU}{2}$ [J]

Plattkondensator

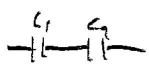
$$C = \varepsilon_0 \varepsilon_r \frac{A}{d} \quad [F]$$

$\varepsilon_0 = 8.85 \cdot 10^{-12}$ F/m permittiviteten i vacuum

ε_r : relativita permittiviteten

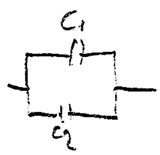
$$U = E \cdot d \quad [V = J/C]$$

Seriekoppling



$$\frac{1}{C_{tot}} = \frac{1}{C_1} + \frac{1}{C_2}$$

Parallellkoppling

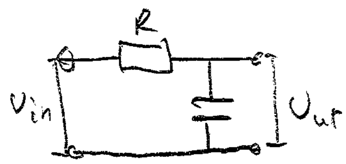


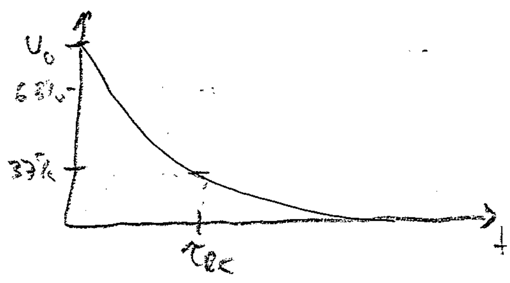
$$C_{tot} = C_1 + C_2$$

RC-krets

Tidskonstant

$\tau = RC$



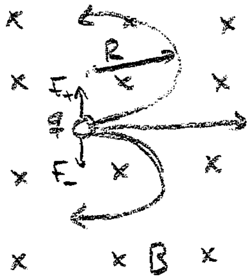


Övning 4. Magnetism. Formler

Högerhandsregeln

$\bar{A} \times \bar{B} = \bar{C}$

Magnetfält



* $\bar{F} = q\bar{v} \times \bar{B}$ $F \perp v$!

$F = qv\sin(\theta)$

$\bar{v}$: hastighet [m/s]

$\bar{B}$: magnetfält $[T = \left(\frac{Wb}{m^2}\right) = \frac{N}{mA} = \frac{kg}{s^2A}]$

* $R = \frac{mv}{|q|B}$

50 μT jordens magnetfält

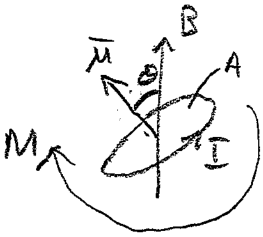
5 mT kylskåpsmagnet

10 T MRI

Magnetisk dipol

Dipolmoment

$\bar{\mu} = NI\bar{A}$ [A m²]



Vridmoment

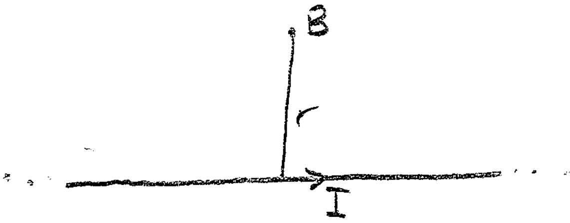
$\bar{M} = \bar{\mu} \times \bar{B}$

$M = \mu B \sin\theta$

Källor till magnetfält

Lång rak ledare

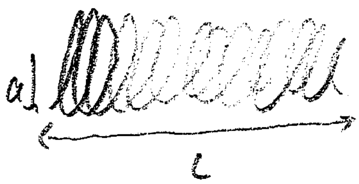
$B = \frac{\mu_0 I}{2\pi r}$ [T]



μ_0 = magnetiska konstanten
$= 4\pi \cdot 10^{-7}$ N/A²

Kort spole (a≫L)

$B = \frac{N\mu_0 I a^2}{2(a^2+z^2)^{3/2}}$ [T]



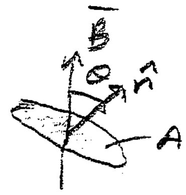
Lång spole och toroid spole (a≪L)

$B = \mu_0 I \frac{N}{L}$ [T]

Övning 5. Induktion. Formler

Magnetiska flödet

$$\Phi = \bar{A} \cdot \bar{B} = AB\cos\theta \quad [Wb = Vs = Tm^2]$$



Inducerad spänning i en spole

$$U = N \frac{d\Phi}{dt} \quad [V]$$

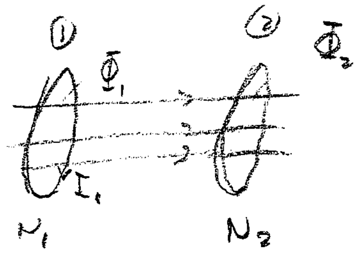
. Riktning från Lenz lag!

Självinduktans

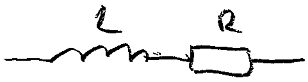
$$L = N \frac{\Phi}{I} \quad \left[H = \frac{Wb}{A} = \frac{Vs}{A}\right]$$

Ömsesidig induktans

$$M = N_1 \frac{\Phi_1}{I_2} = N_2 \frac{\Phi_2}{I_1} \quad [H]$$

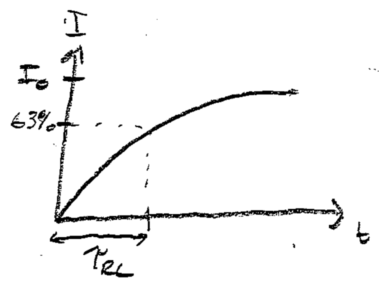


RL-krets



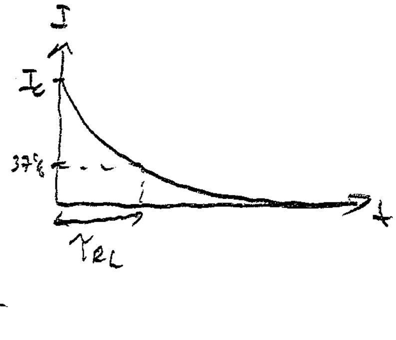
Inkoppling

$$I = I_0 \left(1 - e^{-t/\tau_{RL}}\right)$$



Urkoppling

$$I = I_0 e^{-t/\tau_{RL}}$$



Tidskonstanten $\tau_{RL} = L/R$

Övning 6. Geometrisk optik. Formler

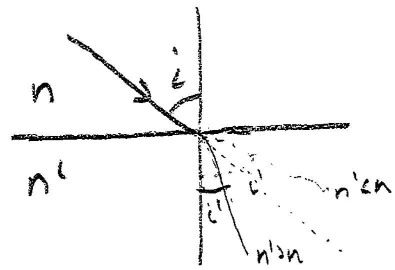
Brytningsindex

$$n = \frac{c}{v} \quad , \quad c \approx 3 \cdot 10^8 \text{ m/s}$$

$$\lambda = \frac{\lambda_0}{n} \quad , \lambda_0 : \text{våglängden i vakuum}$$

Snells lag

$$n \sin(i) = n' \sin(i')$$



Totalreflektion

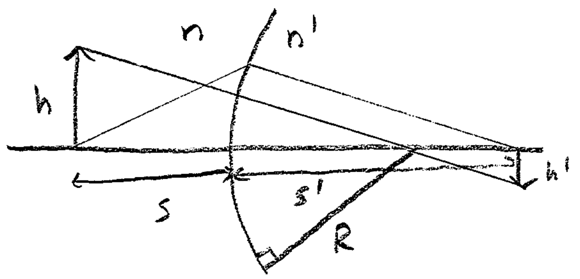
$$\frac{n}{n'} \sin(i) > 1$$

(Finns ingen lösning till snells lag)

Sfärisk gränsyta

$$\frac{n}{s} + \frac{n'}{s'} = \frac{n' - n}{R}$$

$$M = \frac{h'}{h} = -\frac{ns'}{n's}$$

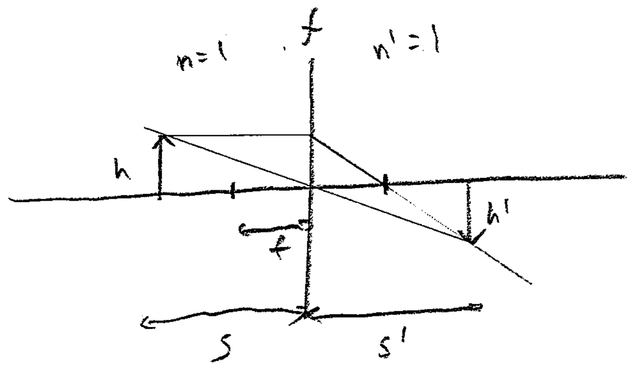


Tunn lins

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

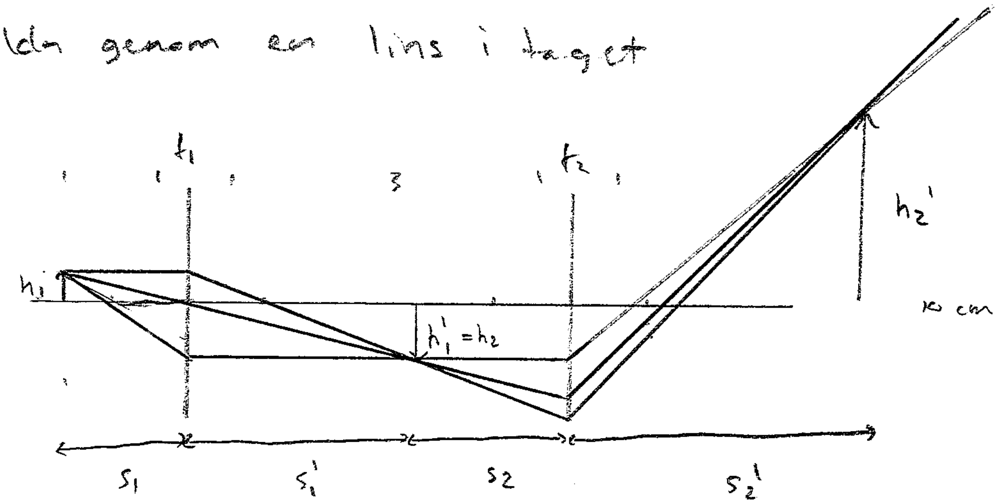
$$M = \frac{h'}{h} = -\frac{s'}{s}$$



Övning 7. Optiska system. Formler

Linssystem

Avbilda genom en lins i taget



$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$|M| = \frac{h'}{h} = \frac{s'}{s} \quad , M_{tot} = M_1 \cdot M_2 \cdot \ldots$$

— parallell

— genom centrum

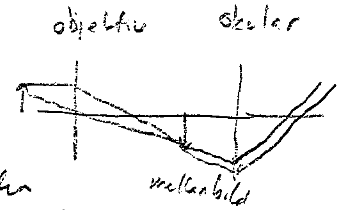
— genom fokus

Två linser

$$\frac{1}{f_{syst}} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

Teleskop och mikroskop

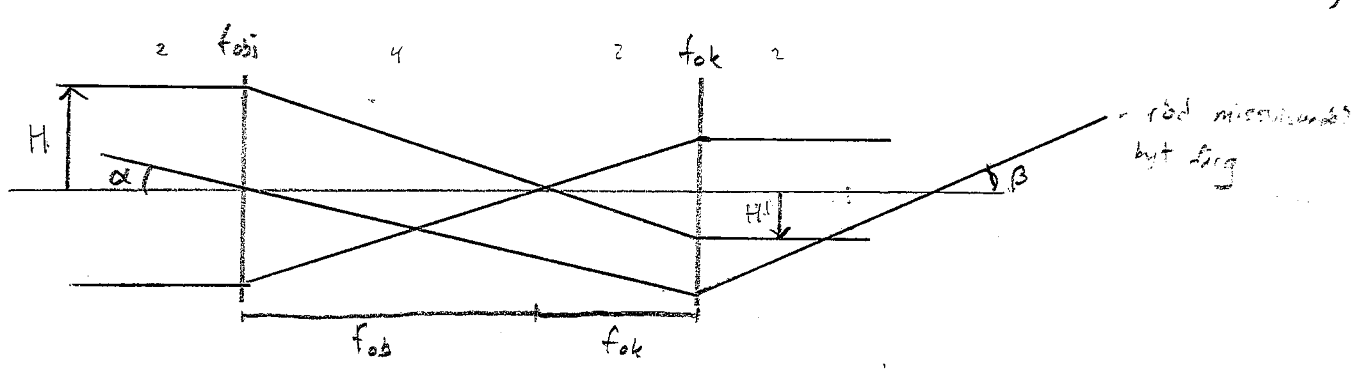
Objektiv: skapar en förstorad mellanbild



Okular: avbildar mellanbilden (oftast så slutbilden hamnar i oändligheten)

Afokala system (teleskop)

Parallella strålar in (objekt i ∞) ger parallella strålar ut (slutbild i ∞)



Vinkelförstoring

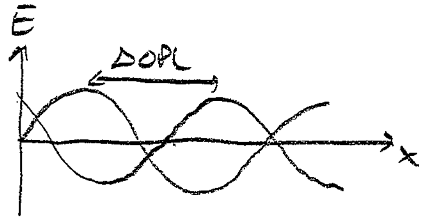
$$|M_\alpha| = \frac{\beta}{\alpha} = \underbrace{\frac{H}{H'} = \frac{f_{ob}}{f_{ok}}}_{\text{OBS! Bara afokalt system}}$$

Övning 8. Interferens. Formler

Optisk väg (optical path length)

Sträckan ljuset färdas, viktat med brytningsindex

$$OPL = nx$$



Fas (ϕ)

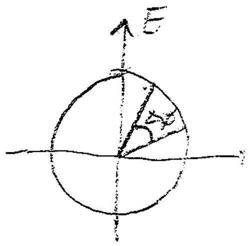
Argumentet till sin/cos "vinkeln"

Ex. $\sin(kx-\omega t)$ $\qquad \phi = kx - \omega t$

Fasskillnad $\Delta\phi$

Mått på hur mycket två strålar från samma källa är förskjutna relativt varandra.

$$\Delta\phi = \frac{2\pi}{\lambda}\Delta OPL = (k\cdot\Delta OPL)$$



Interferens

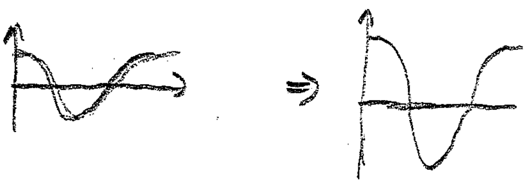
Fälten adderas och ger en total intensitet

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(\Delta\phi)$$

Maximal konstruktiv interferens

$\Delta\phi = 2\pi m$

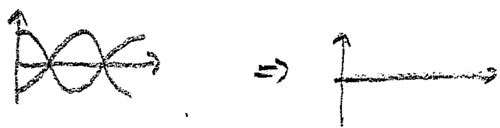
$\Delta OPL = m\lambda$, $m = 0, \pm 1, \pm 2, \ldots$



Maximal destruktiv interferens

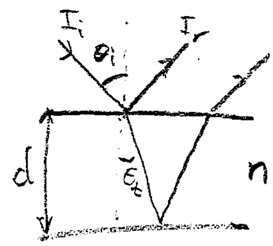
$\Delta\phi = 2\pi m + \pi$

$\Delta OPL = (m+\frac{1}{2})\lambda$, $m = 0, \pm 1, \pm 2, \ldots$



Tunnt skikt ($d \approx \lambda$)

$$\Delta OPL = 2nd\cos(\theta_t) + \begin{cases} \lambda/2 & \text{udda antal ggr refl. mot tätare medium} \\ 0 & \text{annars} \end{cases}$$



Vinkelrät reflektion i en gränsyta

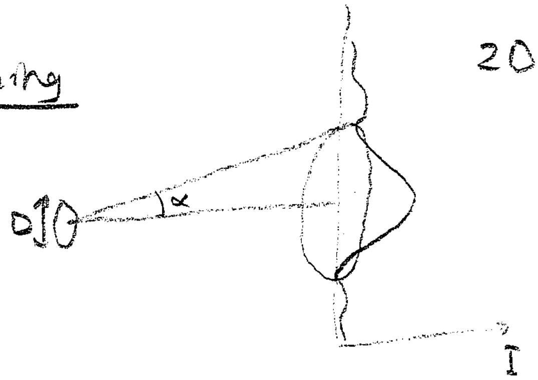
$$R = \frac{I_R}{I_i} = \left(\frac{n_2-n_1}{n_2+n_1}\right)^2 , \quad T+R=1$$

övning 9. Diffraktion . Formler

20'

Diffraktion i cirkulär öppning

$$\sin(\alpha) = \frac{1{,}22\lambda}{D}$$

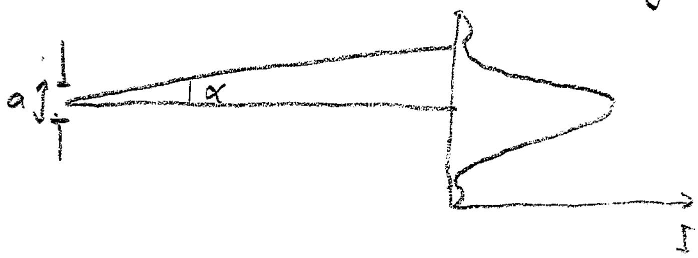


α - vinkeln till första min

Diffraktion i enkelspalt

Bara en riktning!

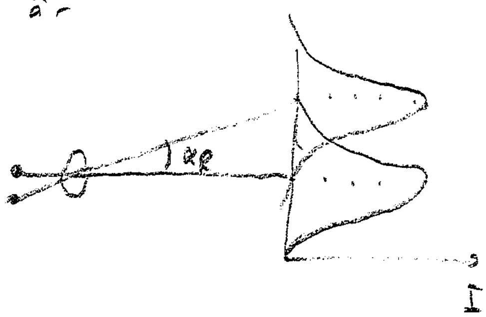
$$\sin(\alpha) = \frac{\lambda}{a}$$



Upplösning

Minsta vinkeln som går att upplösa är

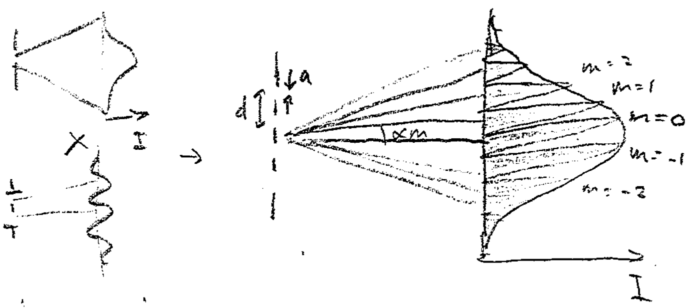
$$\sin(\alpha_R) = \frac{1{,}22\lambda}{D}$$



Gitter

Diffraktionsmönster, fast bara hög intensitet i vissa riktningar

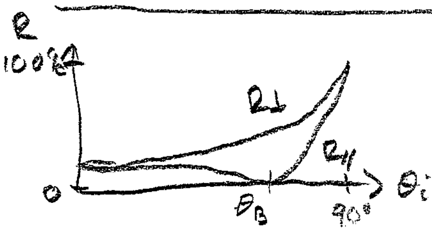
$$\sin(\alpha_m) = \frac{m\lambda}{d}$$



Polarisation

Den riktning som E-fältet varierar i.

Polarisation och reflektans



θ_B : Brewstervinkeln