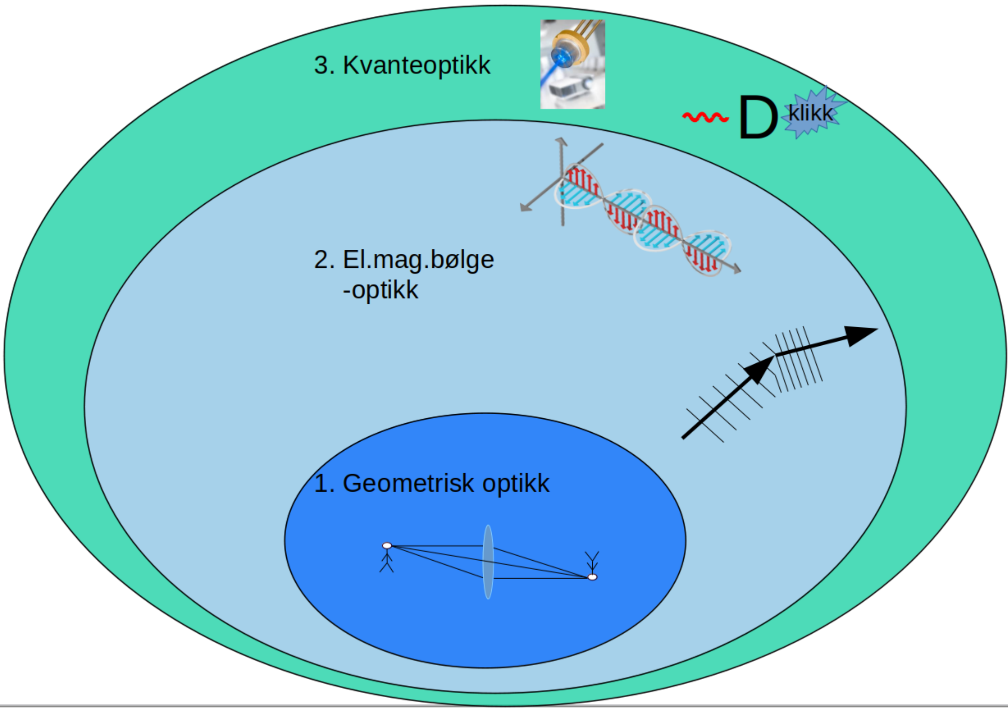
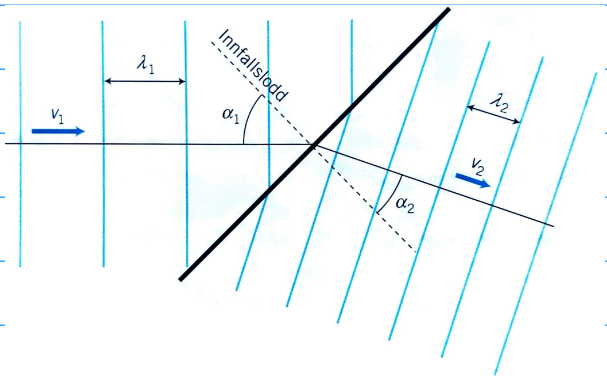
Lys

Teorier for lys:



Snells brytningslov



$$\frac{\sin\alpha_1}{\sin\alpha_2} = \frac{v_1}{v_2}$$

Def. brytningsindeks: $n = \frac{c_0}{c} = \frac{\text{lysfarten i vakuum}}{\text{lysfarten i stoffet}} \Rightarrow c = \frac{c_0}{n}$

For vakuum: $n = 1$

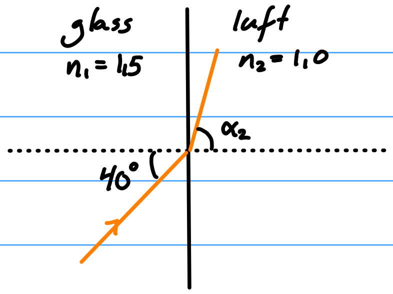
luft: $n \approx 1$

vann: $n = 1{,}33$

glass: $n \approx 1{,}5$

Snells lov: $\frac{\sin\alpha_1}{\sin\alpha_2} = \frac{c_1}{c_2} = \frac{c_0/n_1}{c_0/n_2} = \frac{n_2}{n_1} \Rightarrow$ $\boxed{n_1 \sin\alpha_1 = n_2 \sin\alpha_2}$

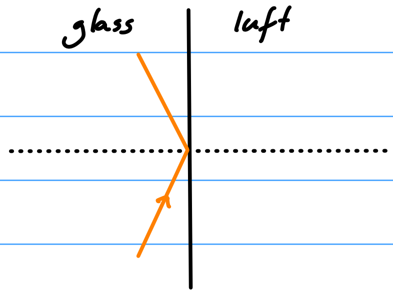
Eks:



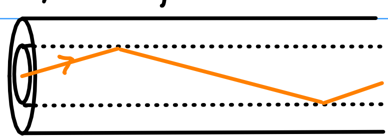
$$\sin\alpha_2 = \frac{n_1 \sin\alpha_1}{n_2} = 1{,}5 \sin 40°$$

$$\alpha_2 \approx 75°$$

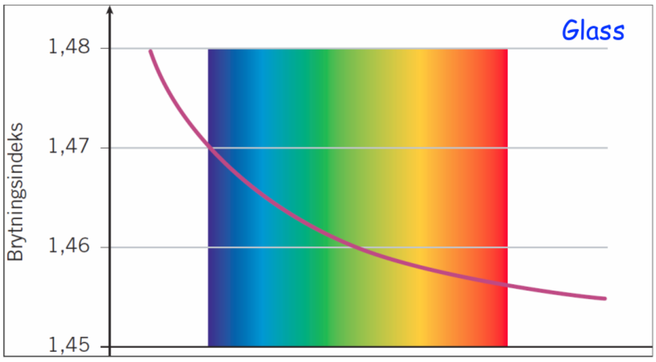
Totalrefleksjon:

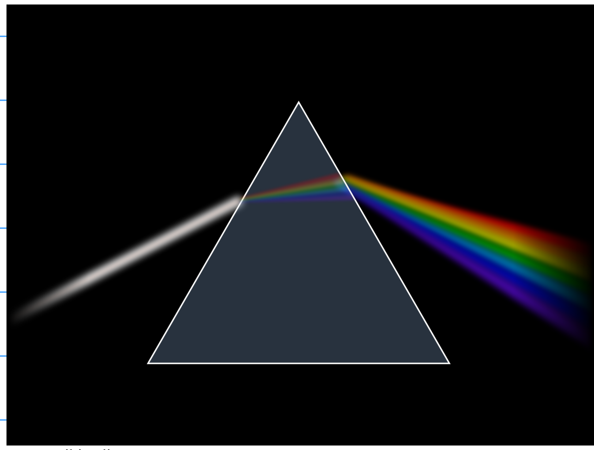


Optisk fiber:



Dispersjon: Brytningsindeksen avhenger (litt) av bølgelengden:

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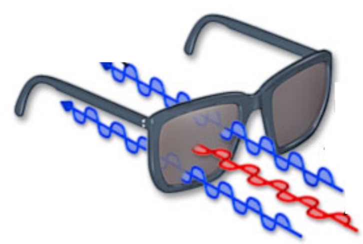
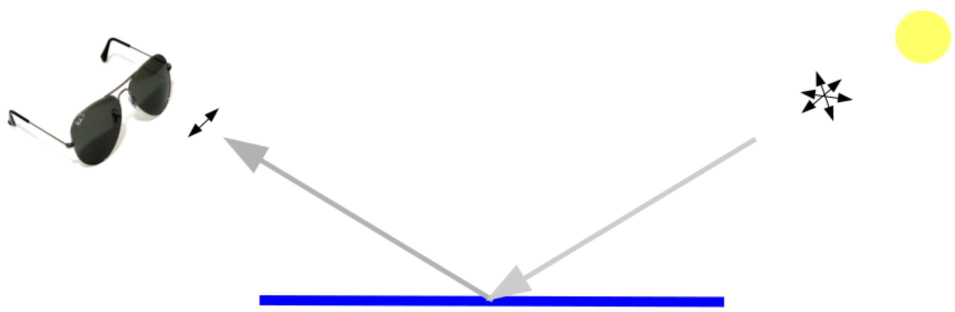
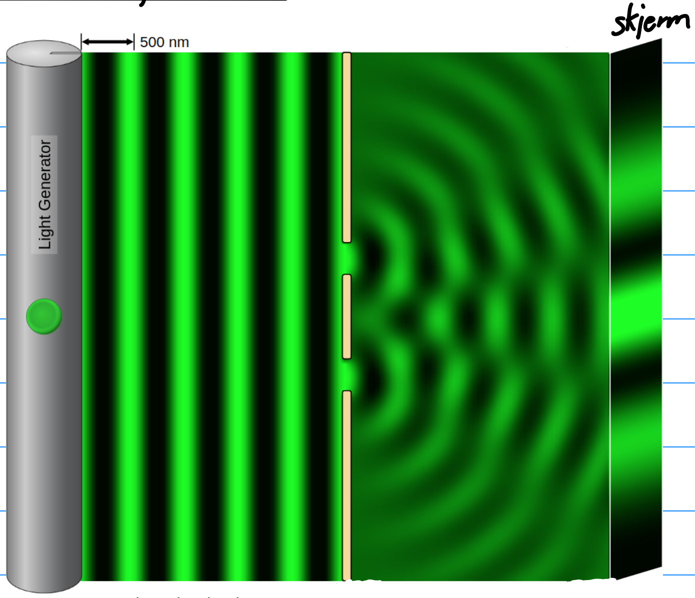
Polarisasjon av lys



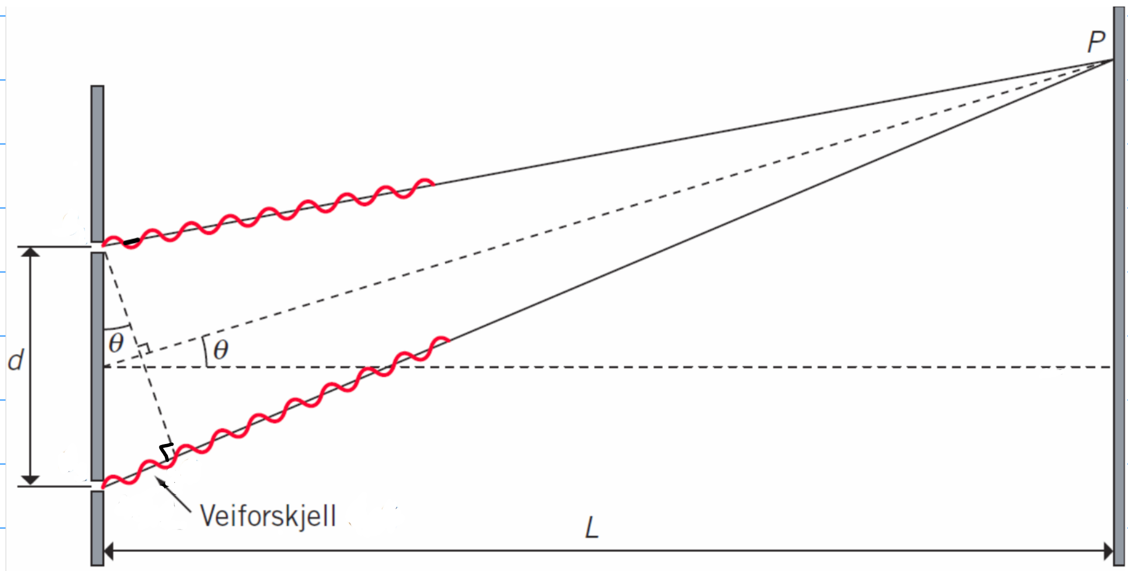


Interferens



phet.colorado.edu

$$f = \frac{c}{\lambda} = \frac{3{,}0 \cdot 10^8 \,\frac{m}{s}}{500\,nm} = 6{,}0 \cdot 10^{14}\,Hz$$



Konstruktiv interferens i P : veiforskjell = $n\lambda$

↳ heltall, orden (ikke brytn.ind.)

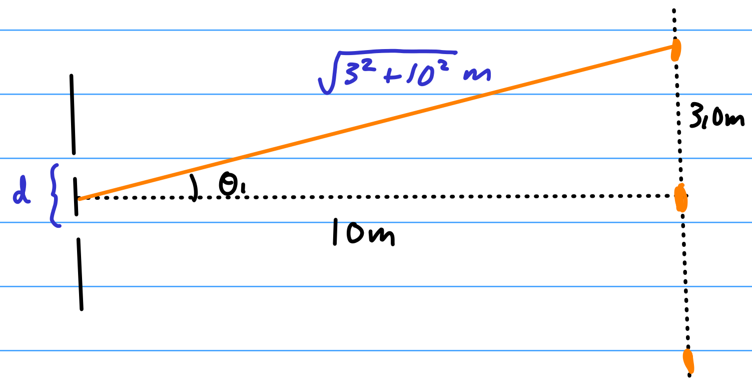
$$\boxed{d \sin\theta_n = n\lambda}$$

Eks: • Spalteavstand $d = 2{,}0\,\mu m$.

• Skjerm $L = 10\,m$ borte.

• Første maksimum 3,0m fra sentralt maksimum.

Finn λ.

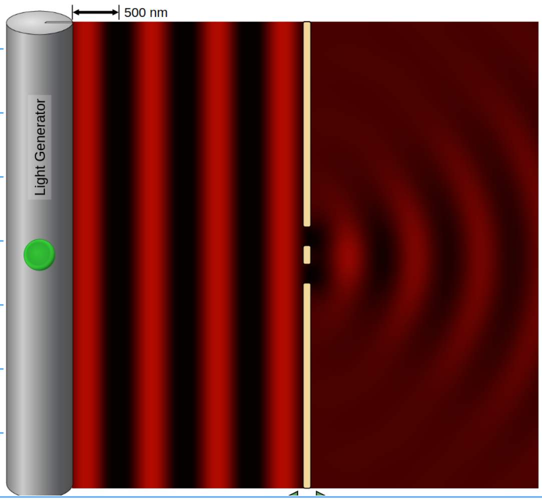


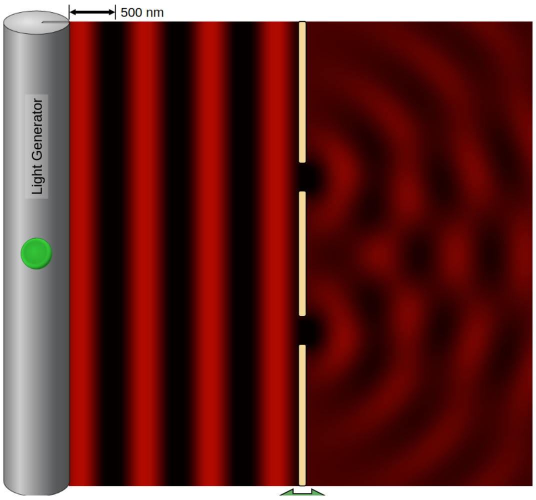
$$\lambda = \frac{d\sin\theta_n}{n} \underset{n=1}{=} d\sin\theta_1 = d\,\frac{3{,}0\,m}{\sqrt{109}\,m} = \underline{570\,nm}$$

Diffraksjon / bøying

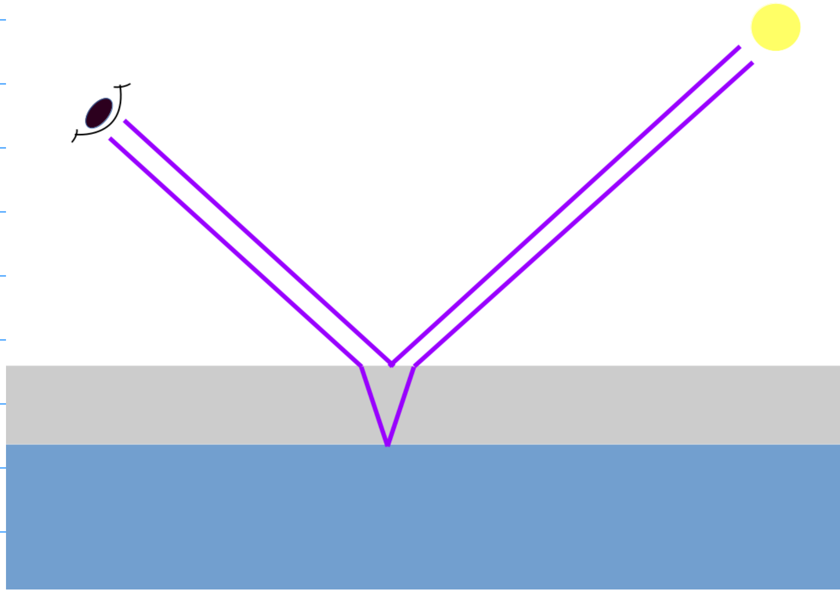
Hva er det minste man kan se i mikroskop?

Svar: $d = \frac{\lambda}{2}$ (diffraksjonsgrensen)



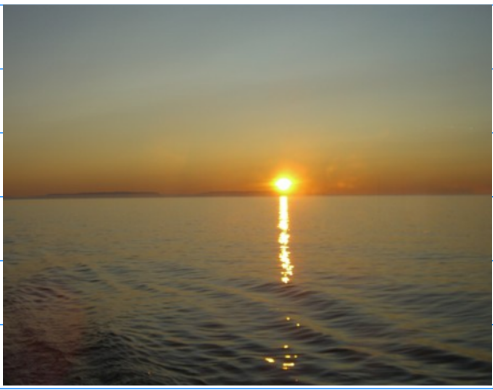


Tynnfilminterferens



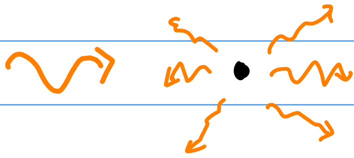
Fe^{2+} oppløst nede i myra.
Ved overflaten oksideres Fe^{2+} til Fe^{3+}, danner $Fe(OH)_3$, tynn film.

Spredning



Hvorfor er himmelen blå og solnedgangen rød?

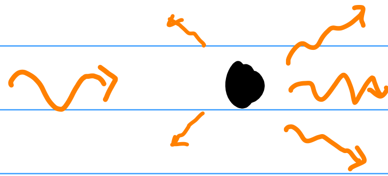
Liten partikkel/molekyl $< \lambda$:



spredning $\propto \frac{1}{\lambda^4}$

(Rayleighspredning)
Eks: blå himmel

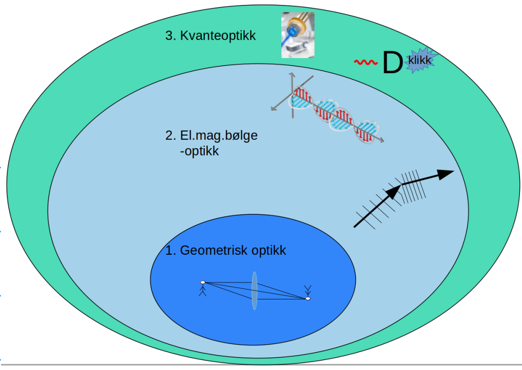
Stor partikkel $> \lambda$:



spredning uavh. av λ

(Mie-spredning)
hvite skyer, melk

Fotoner – lyskvanter



Lys oppstår og absorberes i små energipakker / lyskvanter: **Fotoner**

Energi $E_f = hf$, h : Plancks konst.

$h = 6{,}63 \cdot 10^{-34}\,Js$

$$E_f = \frac{hc}{\lambda}.$$

Hva menes med "stråling med høy energi"?

Upresist og forvirrende! Kan bety

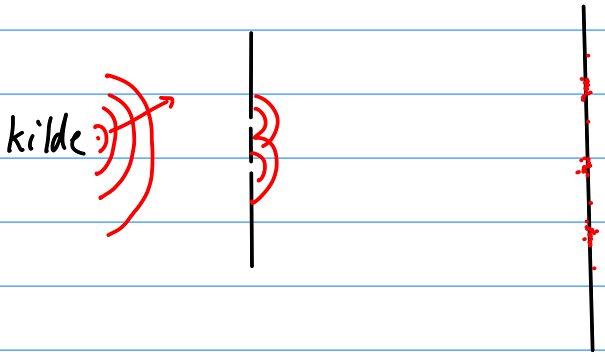
1) Sterk stråling / stor bølge / stor effekt (W), mange fotoner / sek
2) Fotoner med høy energi, dvs stor frekvens / liten bølgelengde

Dette er to forskjellige ting!

Som oftest bør man tenke på lys som

- fotoner / partikler når lys oppstår eller absorberes
- bølger underveis

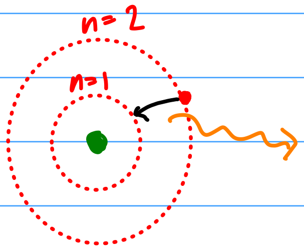
Eks:



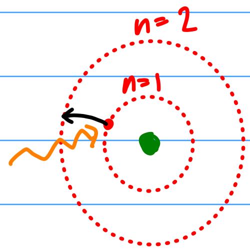
Absorpsjon og emisjon av atomer

Atomer har tillatte energinivåer:

Emisjon: Absorpsjon:

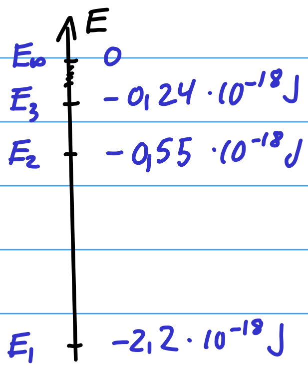


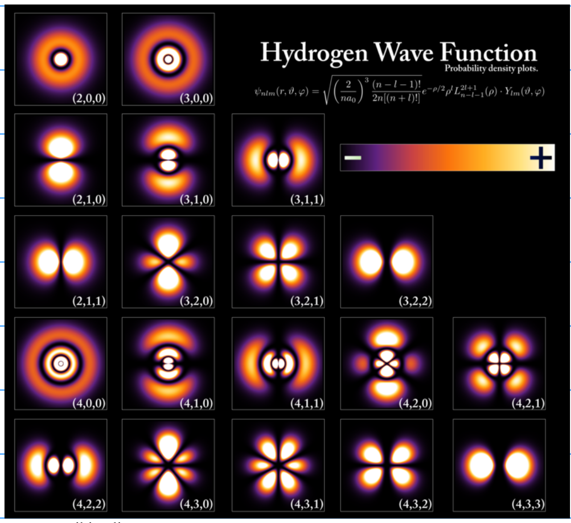
$hf = E_2 - E_1$



Energinivåene i H-atomet:

$$E_n = -\frac{B}{n^2}, \quad B = 2{,}18 \cdot 10^{-18}\,J$$



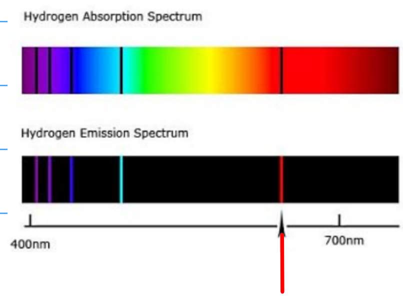


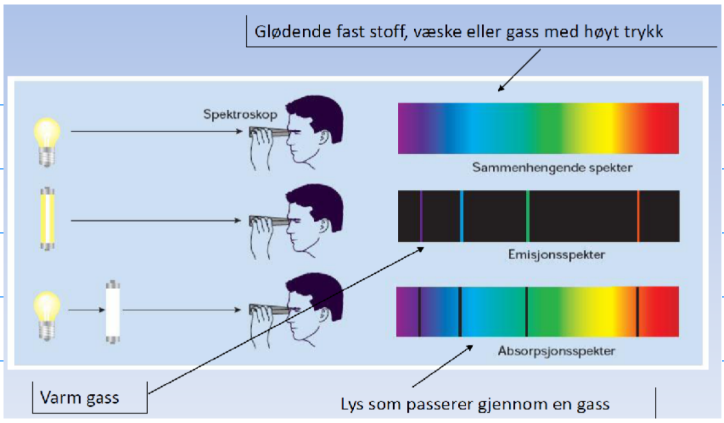
en.wikipedia.org

Eks: Hvilken bølgelengde har strålingen fra H når atomet går fra E_3 til E_2?

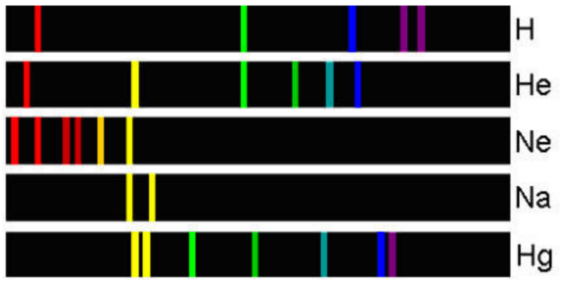
$$E_f = E_3 - E_2 = -B\left(\frac{1}{3^2} - \frac{1}{2^2}\right) = B\left(\frac{1}{4} - \frac{1}{9}\right) = 3{,}03 \cdot 10^{-19}\,J$$

$$E_f = hf = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E_f} = 656\,nm$$





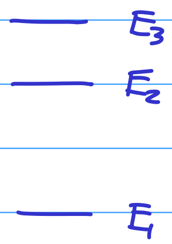
Emisjonsspektere, karakteristisk for hver gass.
Avh. av energiforskjeller mellom energinivåer.



Også molekyler har karakteristiske emisjonsspektre.

Kan detektere gasser optisk.

Eks: Et atom har energinivåene E_1, E_2 og E_3. Ved overgangen $E_3 \rightarrow E_1$ blir det sendt ut lys med bølgelengden 400 nm. Ved overgangen $E_3 \rightarrow E_2$ blir det sendt ut lys med bølgelengden 1200 nm. Hva blir bølgelengden når atomet går fra E_2 til E_1?



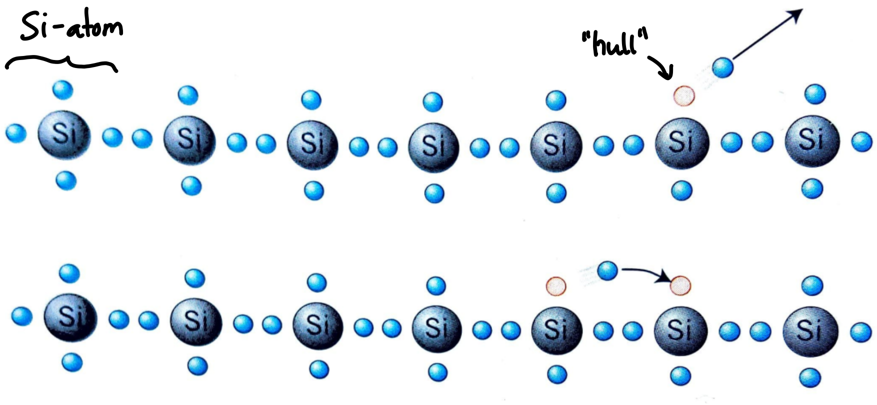
$$E_3 - E_1 = hf_{3\to1} = \frac{hc}{\lambda_{3\to1}} = 4{,}97 \cdot 10^{-19}\,J$$

$$E_3 - E_2 = hf_{3\to2} = \frac{hc}{\lambda_{3\to2}} = 1{,}66 \cdot 10^{-19}\,J$$

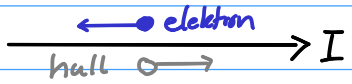
$$E_2 - E_1 = (4{,}97 - 1{,}66) \cdot 10^{-19}\,J = 3{,}31 \cdot 10^{-19}\,J = \frac{hc}{\lambda_{2\to1}}$$

$$\Rightarrow \lambda_{2\to1} = 600\,nm$$

Halvledere, pn-overganger: LED, laserdioder, detektorer, solceller

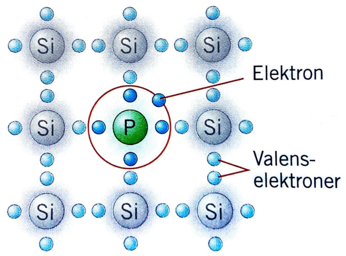


Strøm i en halvleder:

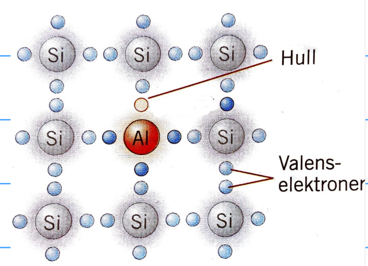


Doping av halvledere:

n-type:

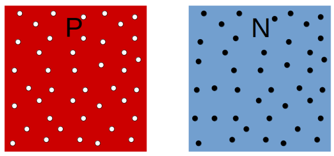


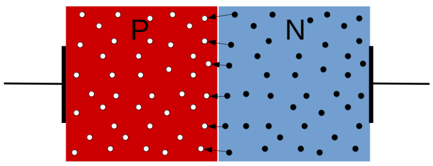
p-type:

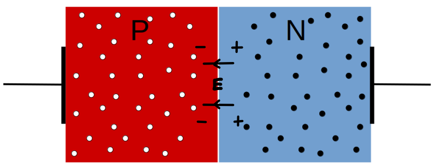


Grimenes, Jestad, Sletbak: Grunnleggende fysikk for universitet og høgskole

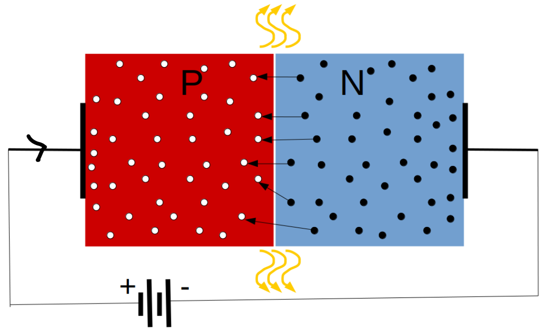
pn-overgang / diode:







Diode i lederetning: LED, laserdiode



Detektor, solcelle: