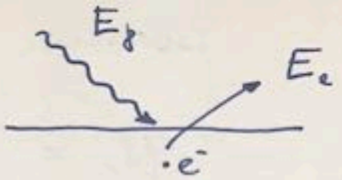
(11) Fotoefekt



$$E_e = E_\gamma - E_i$$

$$\lambda = 436\ \text{nm} \Rightarrow E_\gamma = \frac{hc}{\lambda} = \frac{1240\ \text{eV nm}}{436\ \text{nm}} \sim 3\ \text{eV}$$

$$= 2.84\ \text{eV}$$

$$E_i = 1{,}9\ \text{eV}$$

$$E_e = E_\gamma - E_i \cong (3 - 1{,}9)\ \text{eV} = 0{,}94\ \text{eV}$$

(IV.14) Sevanje črnega telesa

Spekter:
$$\frac{dj}{d\nu} = \frac{2\pi h}{c^2} \frac{\nu^3}{e^{h\nu/kT} - 1}$$

$\Downarrow$ iz frekvence v valovno dolžino

$$c = \nu\lambda \quad / \ln, ' \Rightarrow 0 = \frac{d\nu}{\nu} + \frac{d\lambda}{\lambda}$$

$$\frac{dj}{d\lambda} = \frac{dj}{d\nu}\frac{d\nu}{d\lambda} = \frac{2\pi h}{c^2} \frac{\nu^3}{e^{hc/\lambda kT} - 1} \cdot \left(-\frac{c}{\lambda^2}\right)$$

$$= 2\pi h c^2 \frac{\lambda^{-5}}{e^{hc/\lambda kT} - 1} \quad ; \quad \Delta j \cong \frac{dj}{d\lambda} \cdot \underbrace{\Delta\lambda}_{1\text{nm}}$$

$$\lambda_0 = 669\ \text{nm}, \quad T = 1000\ \text{K}, \quad k_B = 9 \cdot 10^{-5}\ \text{eV/K}$$

$$\frac{hc}{\lambda kT} = \frac{1240\ \text{eV nm}}{670\ \text{nm}\ 0.09\ \text{eV}} = 21.5 > 1 \quad (\sim \text{nizka } T)$$

$$\frac{\Delta j'}{\Delta j} \cong \frac{e^{hc/\lambda kT}}{e^{hc/\lambda kT'}} = R \Rightarrow \frac{hc}{\lambda k}\left(\frac{1}{T} - \frac{1}{T'}\right) = \ln R$$

$$\Rightarrow 1 - \frac{T}{T'} = \frac{\lambda k T}{hc} \ln R$$

$$\parallel$$

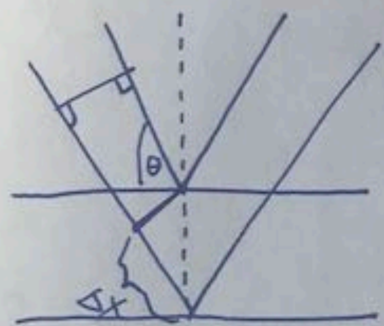
$$1 - \frac{T}{T+\Delta T} = 1 - \frac{1}{1+\frac{\Delta T}{T}} \approx \frac{\Delta T}{T}$$

$$\frac{\Delta T}{T} = \frac{\lambda k T}{hc} \ln R \sim 0{,}7 \, \frac{1}{21} \sim 0{,}033$$

a) $\Delta T = T \cdot 0{,}033 = 33\,K$, $R=2$

b) $\Delta T = 51 K$, $R=3$

(13) Braggovo sipanje



$$\Delta s = 2\Delta x = \underbrace{2d \sin\Theta}_{} = n\lambda$$

Braggov kot, pogoj za resonančno sipanje na kristalu

$\lambda_{DB} = \frac{hc}{pc}$, T^{min} za e^- in n $\quad m_e c^2 = 511\,keV$

$m_n c^2 \sim GeV$

$n\lambda_{DB} = n \frac{hc}{pc} = 2d \sin\Theta$, $d = 0{,}21\,nm$

$$cp = \left(\frac{2d\sin\Theta}{n\,hc}\right)^{-1} = \frac{n\,hc}{2d \sin\Theta} \xrightarrow[\sin\Theta = 1]{\min\; n=1} \frac{hc}{2d} \sim \frac{1240\,eV\,nm}{0{,}42\,nm} \sim 3\,keV$$

$$cp \ll m_e c^2 \text{ in } m_n c^2 \Rightarrow T_e \sim \frac{(cp)^2}{2 m_e c^2} = \frac{9\,keV^2}{1000\,keV} \sim 9\,eV$$

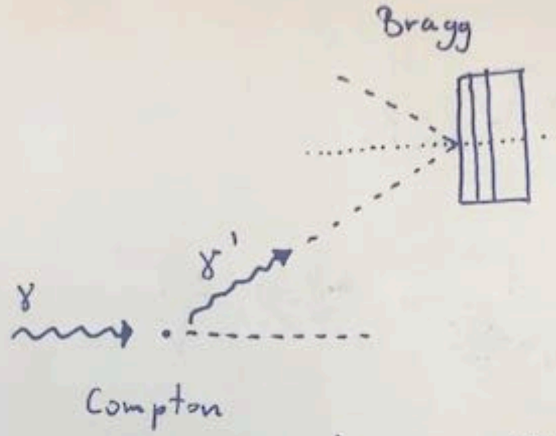
$$T_n \sim \frac{m_e}{m_n} \cdot T_e = \frac{0{,}5}{1000} \cdot 9\,eV \sim 4.5\,meV$$

(14) $U = 17{,}4\,kV$

$d = 0{,}3\,nm$

$\Theta = 75°$

$\delta\alpha = ?$



a) Braggovo sipanje $\lambda = \frac{hc}{eU} = \frac{1{,}240\,eV nm}{17{,}4\,keV} = 0{,}07\,nm$

$2d \sin\alpha = n\lambda$ ($n = 1$)

$\sin\alpha = \frac{\lambda}{2d} = \frac{0.07}{0.6} = 0{,}12\,;\ \alpha = 6.9°$

b) Vmesno Comptonovo sipanje $\lambda \to \lambda' = \lambda + \lambda_c(1-\cos\Theta)$

$= 0{,}07\,nm + \underbrace{\frac{1{,}24}{511}(1-0{,}26)}_{\delta\lambda = 0{,}0018\,nm \ < \lambda'}$

$\sin\alpha' = \frac{\lambda'}{2d}$

$\alpha' \Rightarrow \delta\alpha = \frac{\delta\lambda}{2d} = \frac{\lambda_c(1-\cos\Theta)}{2d} \sim 0{,}17°$

PRINCIP NEDOLOČENOSTI

$\hbar = h/2\pi$; $\hbar c = 197\,eV\,nm$

$$\delta x\,\delta p \geq \frac{\hbar}{2} \quad \& \quad \delta t\,\delta E \geq \frac{\hbar}{2}$$

① e^- pospešimo z $U = 0{,}1\,MV$, $dU = 50\,V$.
Kolikšna je nedoločenost lege elektrona?

$$T_e = eU = 0{,}1\,MeV \approx m_e c^2 = 0{,}5\,MeV$$

$$\Delta T = e\,dU = 50\,eV$$

$$pc = \sqrt{T(T + 2mc^2)}$$

$$\Delta pc = \frac{dpc}{dT}\cdot \Delta T = \frac{1}{2}\,\frac{2T + 2mc^2}{\sqrt{T(T+2mc^2)}}\,\Delta T$$

$$= \frac{0{,}1 + 0{,}5}{\sqrt{0{,}1\,(0{,}1 + 1{,}2)}}\,50\,eV \cong 90\,eV$$

$$\Delta x > \frac{\hbar c}{2\Delta pc} \cong \frac{200\,eV\,nm}{180\,eV} \sim 1{,}1\,nm$$

② Razpad η mezona, $\tau_\eta = 7\cdot 10^{-19}\,s$, $m_\eta c^2 \cong 550\,MeV$

$$\Delta E\,\Delta t \geq \frac{\hbar}{2}, \quad \Delta t < \tau_\eta, \quad \Delta E \gtrsim \frac{\hbar c}{2\tau_\eta c} = \frac{200\,eV\,nm}{6\cdot 10^8\frac{m}{s}\,7\cdot 10^{-19}\,s}$$

$$= 470\,eV$$

$$\frac{\delta m_\eta}{m_\eta} \sim \frac{470\,eV}{550\cdot 10^6\,eV} = 8{,}5\cdot 10^{-7}$$