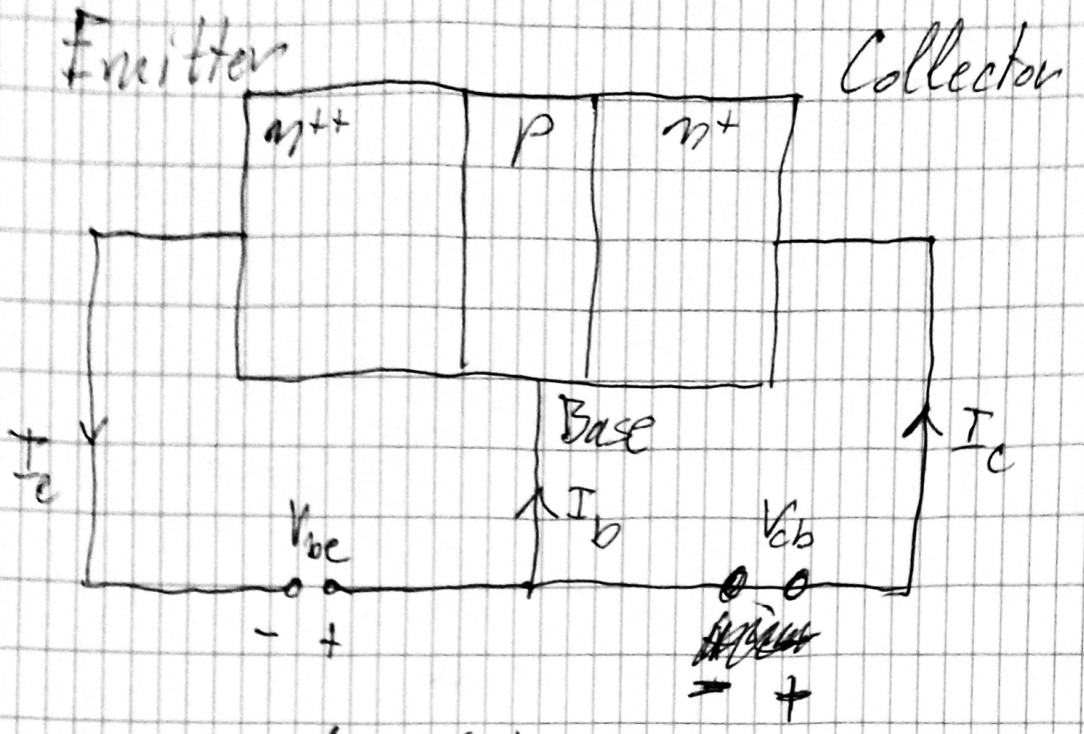
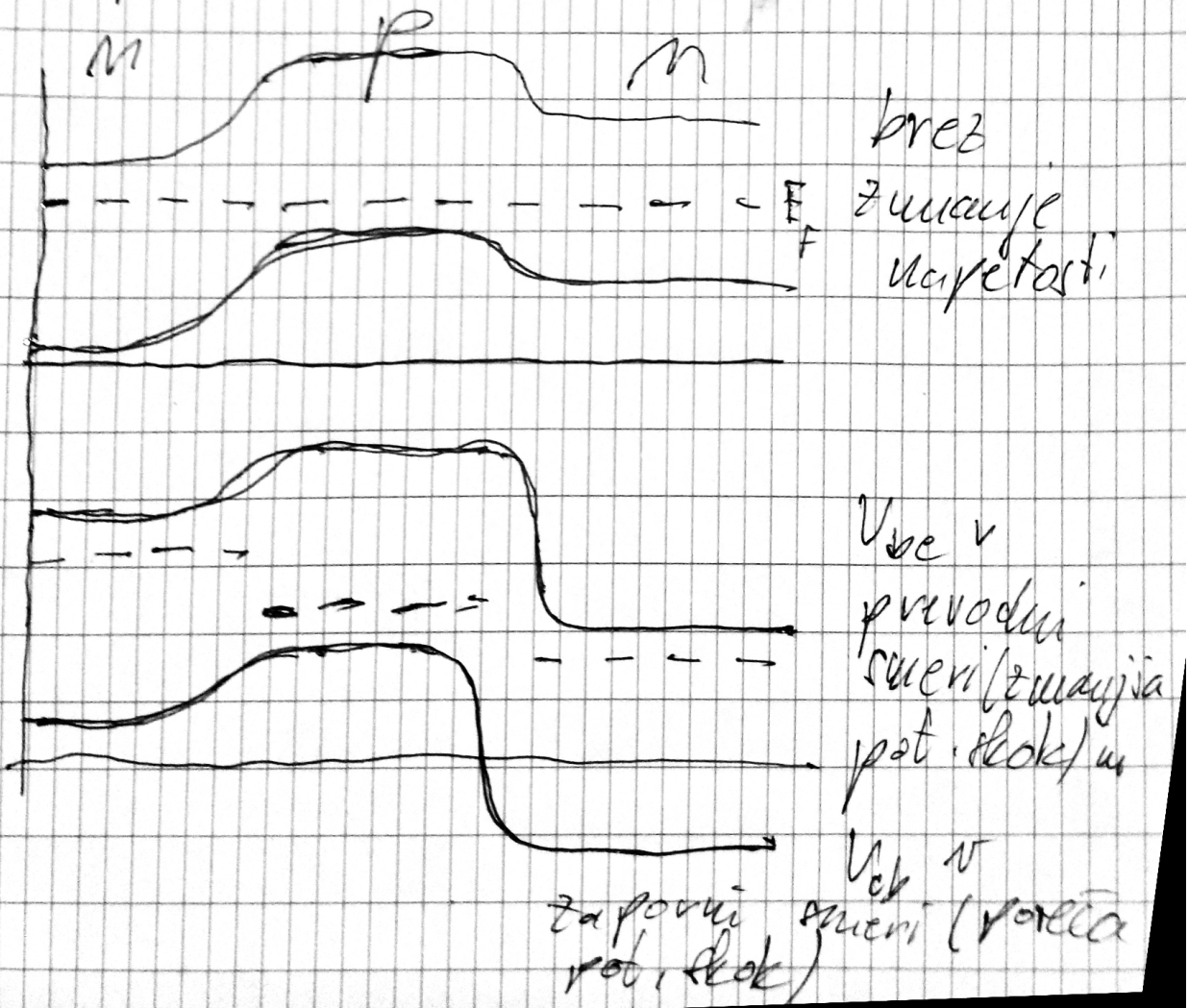
Bipolarni tranzistor

(BJT = Bipolar Junction Transistor)



n-p-n tranzistor



$$I_c = \alpha I_e + I_{cb} \approx \alpha I_e$$

$\alpha = 0,95 - 0,98$ majhno ojačanje

$\alpha \sim 0,995$ veliko -"-

$$I_b = I_e - I_c = (1-\alpha) I_e$$

Stik med E in B v prevodni smeri $\Rightarrow$ I_b eksp. naraščа z V_{be}

$$I_b \approx I_0 e^{V_{be}/kT} \rightarrow$$

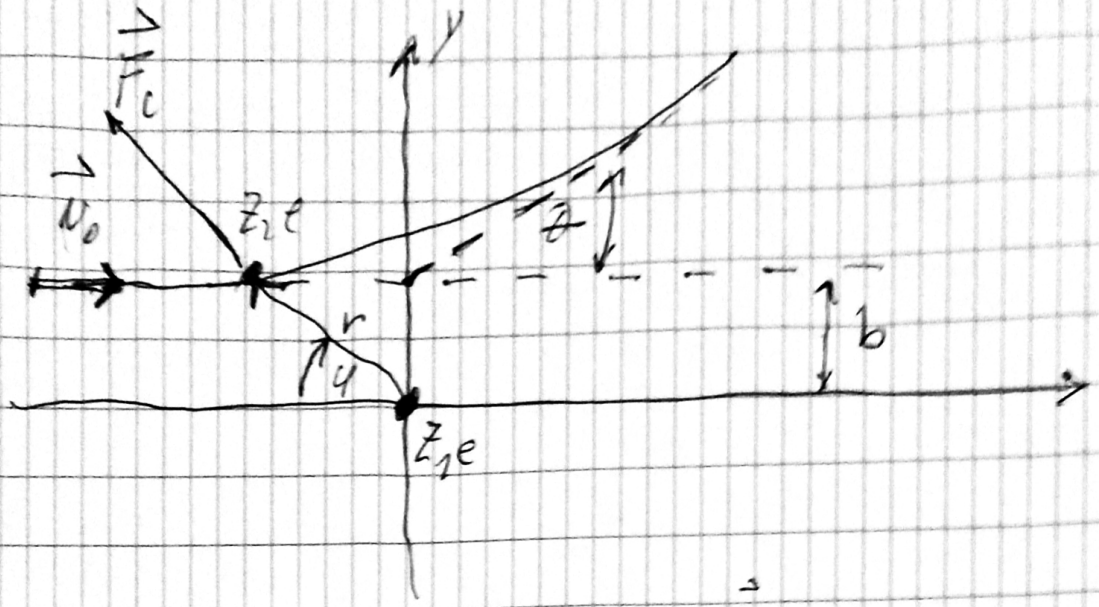
$\rightarrow$ zmotno visoki I_e in I_c

$$I_e = \frac{I_b}{1-\alpha}$$

$$I_c = \frac{\alpha}{1-\alpha} I_b = \frac{\alpha}{1-\alpha} I_0 e^{V_{be}/kT}$$

z V_{be} kvantitativno relat. majhen I_b, ki pa povzroča veliko večji ($\sim 0x - 500x$) I_c

Rutherford-ův pokus



$$F_c = \frac{z_1 z_2 e^2}{4\pi\varepsilon_0 r^2}$$

$$\frac{d\vec{\Gamma}}{dt} = \vec{M} = \vec{r} \times \vec{F} = \vec{0}$$

$$\vec{\Gamma} = \text{konst.} = \Gamma_0$$

$$\vec{\Gamma} = \vec{r} \times \vec{p} = \vec{r} \times m\vec{v}$$

$$x = -r\cos\varphi$$

$$y = r\sin\varphi$$

$$\vec{v} = (\dot{x}, \dot{y})$$

$$\Rightarrow \Gamma = \ldots = mr^2\dot{\varphi}$$

$$\Gamma_0 = m v_0 b = m r^2 \dot{\varphi}$$

$$F_{cy} = m\frac{dv_y}{dt} = m\frac{dv_y}{d\varphi}\dot{\varphi} = \frac{z_1 z_2 e^2 \sin\varphi}{4\pi\varepsilon_0 r^2}$$

$$r^2 = \frac{v_0 b}{\dot{\varphi}}$$

$$\frac{z_1 z_2 e^2}{4\pi\varepsilon_0}\sin\varphi\,\frac{\dot{\varphi}}{v_0 b} = m\frac{dv_y}{d\varphi}\dot{\varphi}$$

(d)

$$\int_0^{v_y} dv_y = \underbrace{\frac{z_1 z_2 e^2}{4\pi\varepsilon_0 m v_0 b}}_{K} \int_0^{\varphi} \sin\varphi \, d\varphi$$

$$v_x = \frac{K}{v_0}(1-\cos\varphi)$$

$$v_y(\varphi = \pi - \theta) = v_0 \sin\theta = K(1+\cos\theta)$$

$$K(1+\cos\theta) = v_0 \sin\theta$$

$$\frac{K}{v_0} = \frac{z_1 z_2 e^2}{4\pi\varepsilon_0 m v_0^2 b} = \frac{\sin\theta}{1+\cos\theta} = \operatorname{tg}\frac{\theta}{2}$$

$$b = \frac{z_1 z_2 e^2}{4\pi\varepsilon_0 m v_0^2} \cdot \frac{1}{\operatorname{tg}\frac{\theta}{2}}$$

↓

vpadni parameter

Če imamo en sipalni center (en atom Au) se vsi He ioni z vpadnim parametrom med b in $b+db$ sipajo pod kotom θ in $\theta + d\theta$.

(e)

$$db \propto \frac{d\theta}{\operatorname{tg}^2\frac{\theta}{2}} \frac{1}{\cos^2\frac{\theta}{2}} = \frac{d\theta}{\sin^2\frac{\theta}{2}}$$

(ce so projektili enakomerno porazd. po površini)

$$dN \propto 2\pi b\, db \propto \underbrace{\frac{1}{\operatorname{tg}\frac{\theta}{2}}}_{b} \underbrace{\frac{d\theta}{\sin^2\frac{\theta}{2}}}_{db}$$

$$\frac{dN}{d\Omega} \propto \frac{dN}{\sin\theta\, d\theta} = \frac{dN}{2\sin\frac{\theta}{2}\cos\frac{\theta}{2}\, d\theta}$$

↑

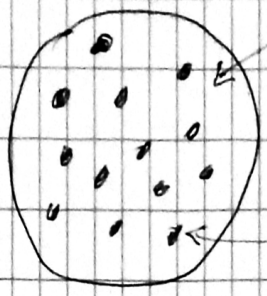
št. projektilov tipanih v prostorski kot $d\Omega$ (med θ in $\theta + d\theta$)

$$\frac{dN}{d\Omega} \propto \underbrace{\frac{\cos\frac{\theta}{2}}{\sin\frac{\theta}{2}}}_{b} \underbrace{\frac{d\theta}{\sin^2\frac{\theta}{2}}}_{db} \underbrace{\frac{1}{\sin\frac{\theta}{2}\cos\frac{\theta}{2}}}_{d\Omega}$$

$$\frac{dN}{d\theta} \propto \frac{1}{\sin^4\frac{\theta}{2}} \quad !!$$

(f)

Thompson-ov model atoma



Največja sila, ki bi jo občutil projektil (če pozabimo e⁻):

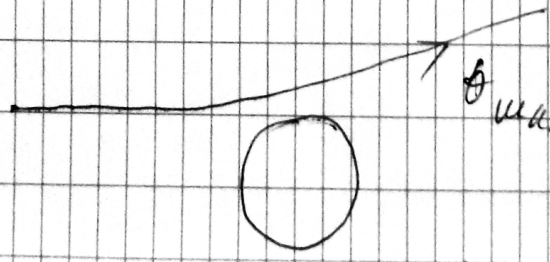
$$F = \frac{Z_1 Z_2 e^2}{4\pi\varepsilon_0 R^2} \leftarrow \text{radij atoma}$$

(pri $r<R$ bi občutil le naboj pri radiju r)

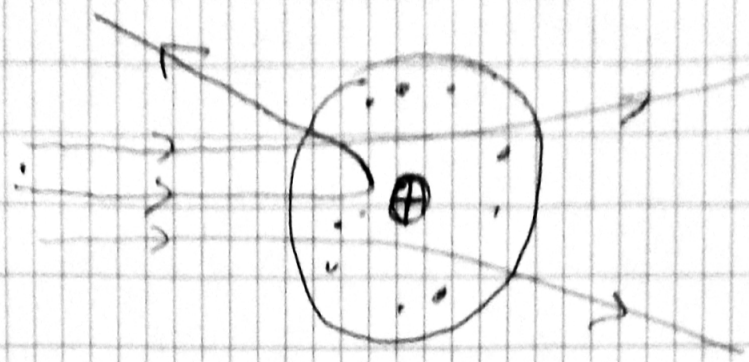
$$\Delta p = F\Delta t \sim \frac{Z_1 Z_2 e^2}{4\pi\varepsilon_0 R^2}\,\frac{2R}{v_0}$$

$$\theta \sim \frac{\Delta p}{p} \sim \frac{Z_1 Z_2 e^2}{4\pi\varepsilon_0 R^2}\,\frac{2R}{v_0}\,\frac{1}{m v_0} \sim$$

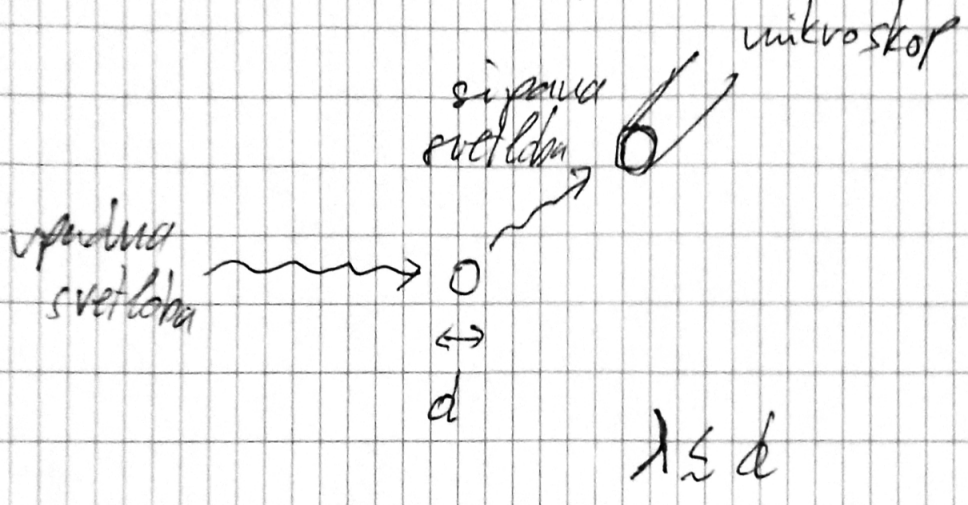
$$\sim 0{,}03^\circ !$$



Rutherford-ov model



Optični mikroskop:



$\lambda \lesssim d$

Valovno-korpuskularni dualizem (:-)

delec z gib. količino p

$$\lambda_B = \frac{h}{p} = \frac{2\pi\hbar}{p}$$

da "dipljemo" predmete z $d \sim 10^{-14}m$

$$\Rightarrow p = \frac{2\pi\hbar}{d} \quad cp \sim \frac{2\pi\hbar c}{d} \sim 120\,MeV$$

Če uporabimo pospešene e^- z 10x nižjo energijo* $\Rightarrow$

$\Rightarrow$ „difrigiramo“ lahko $d \sim 10^{-15}$ m

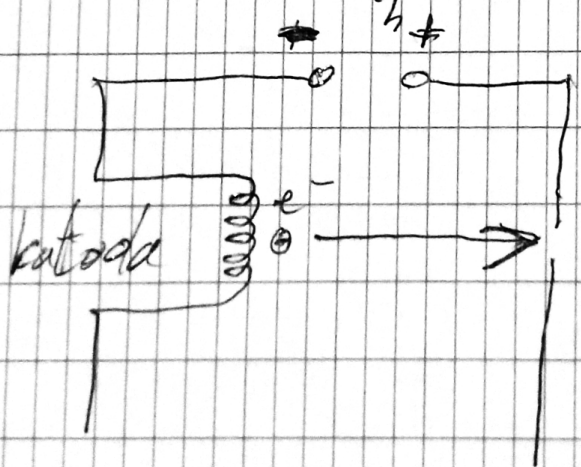
* $E = \sqrt{m^2c^4 + c^2p^2} \approx cp$

e^- se sipajo (Coulombsko) na porazdelitvi naboja v jedru $\rightarrow$

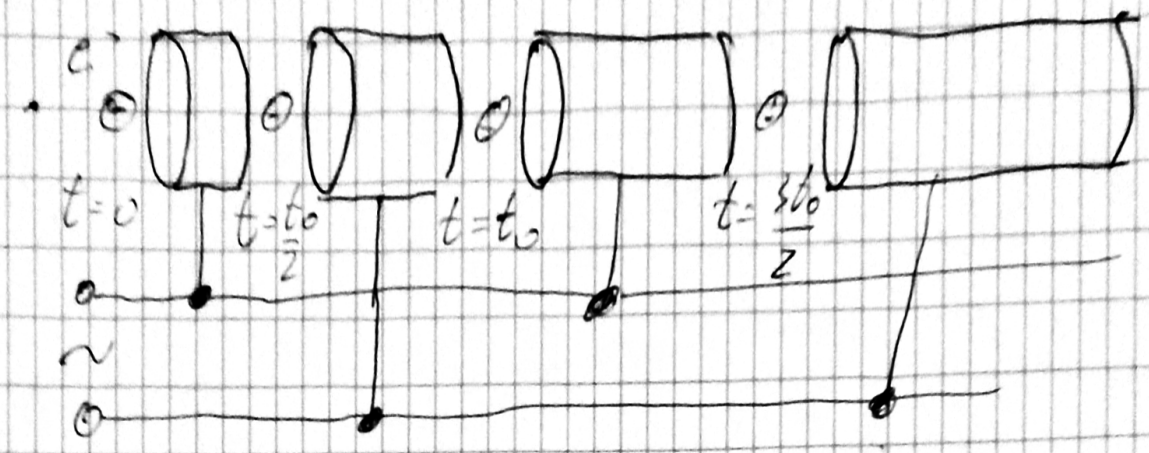
$\rightarrow$ porazdelitev sipanih e^- nudi informacijo o $\rho(r)$

Pospeševanje nabitih delcev

z $\vec{E}$



več stopenj:



$$U = U_0 \sin(\omega t + \varphi)$$

$t = 0$	+	−	+	−
$\frac{t_0}{2}$	−	+	−	+
t_0	+	−	+	−

za $\nu \ll C$ $\quad l_n = v_n \frac{t_0}{2} = \frac{t_0}{2}\sqrt{\frac{2W_{k,n}}{m_1}}$

$$W_{k,n} = e\left[|U_0 \sin\varphi| + |U_0 \sin(\tfrac{\omega t_0}{2} + \varphi)| + |U_0 \sin(\omega t_0 + \varphi)| + \dots\right] =$$

$$= e U_0 \sum_{n=0}^{N} |\sin(\tfrac{\omega n t_0}{2} + \varphi)| =$$

$$= e U_0 \sum_{n=0}^{N} |\sin\tfrac{\omega n t_0}{2}\cos\varphi + \cos\tfrac{\omega n t_0}{2}\sin\varphi|$$

$$= e U_0 \sum_{n=0}^{N} |\sin n\varphi| = e U_0 (N+1) |\sin\varphi| \quad (j)$$

$$l_n \propto \sqrt{n+1}$$