

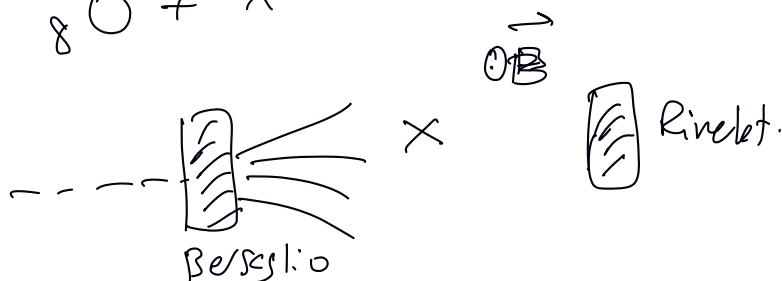
Rutherford



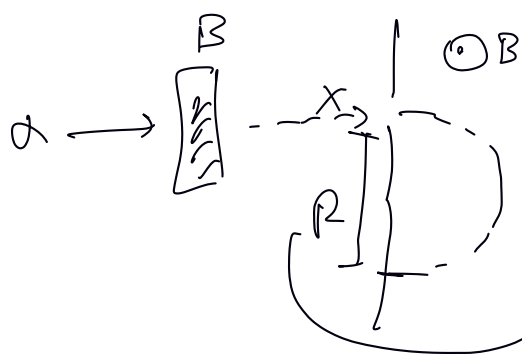
$e^-$ : Thompson 1897

$$e^-, N, \alpha$$

protoni: Rutherford 1918



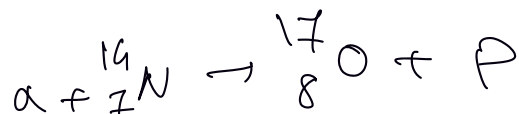
$X$  carica.  $\Rightarrow$  spettroscopia di massa.



$$\vec{F} = m \vec{a} = q (\vec{v} \times \vec{B})$$

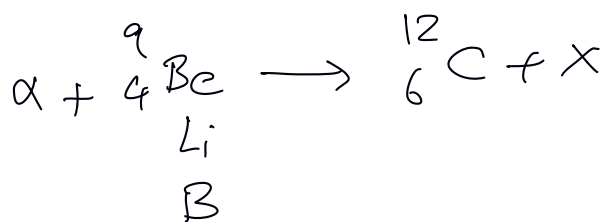
$$a = \frac{q}{m} v B$$

$\frac{q}{m}$  compatibile con ione  $H^+$



Trasmutazione nucleare

Chadwick 1931  $\rightarrow$  Scoperta del neutrone.

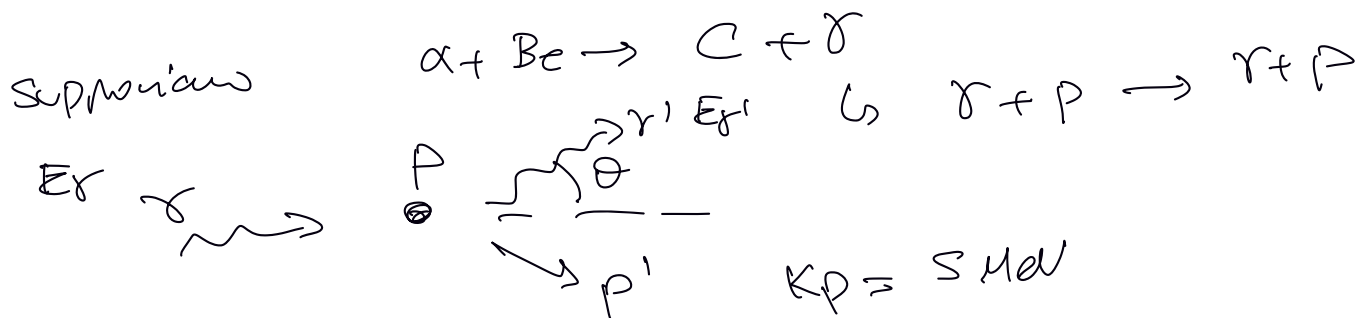


caratteristiche di  $X$

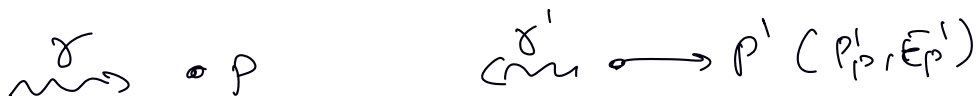
- neutro
- non ionizzante
- molto penetrante

Ipotesi:

- fotoni  $X \equiv \gamma$
- nuove particelle con massa  $m$



$$E_{\gamma'} = \frac{m_p}{E_{p'}} \frac{E_{\gamma}}{1 - \frac{p_{p'}}{E_{p'}} \cos \theta}$$



$$E_{\gamma'} = \frac{m_p}{E_{p'}} \frac{E_{\gamma}}{1 + \frac{p_{p'}}{E_{p'}}$$

$$E_{p'} = m_p + K_p \quad K_p \approx 5 \text{ MeV} \quad \text{dalle misure}$$

$$E_{\gamma'} \approx 0.9 E_{\gamma}$$

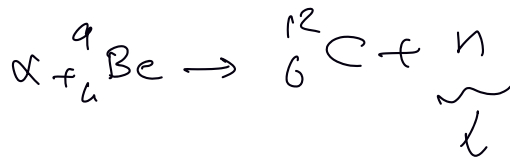
$$E_\gamma + m_p = E_{\gamma'} + m_p + K_p$$

$$\Rightarrow E_\gamma - E_{\gamma'} = K_p$$

$$\sim 0.1 E_\gamma = 5 \text{ MeV} \Rightarrow E_\gamma \approx 50 \text{ MeV}$$

$\Rightarrow$  non era possibile

$\Rightarrow$  Chadwick



$$\frac{|m_n - m_p|}{m_p} \approx 10\%$$

$$m_p = 938.3 \text{ MeV}$$

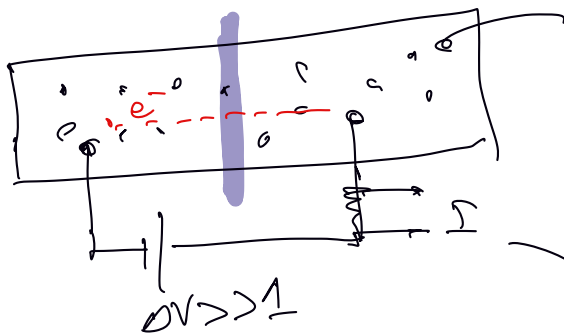
$$m_n = 939.6 \text{ MeV}$$

$$\frac{\Delta m}{m} \approx 1\%$$

$\gamma, \alpha, p, n, e^-$

Scoperte dell'elettrone

Thompson 1897 Nobel 1906  
gas.



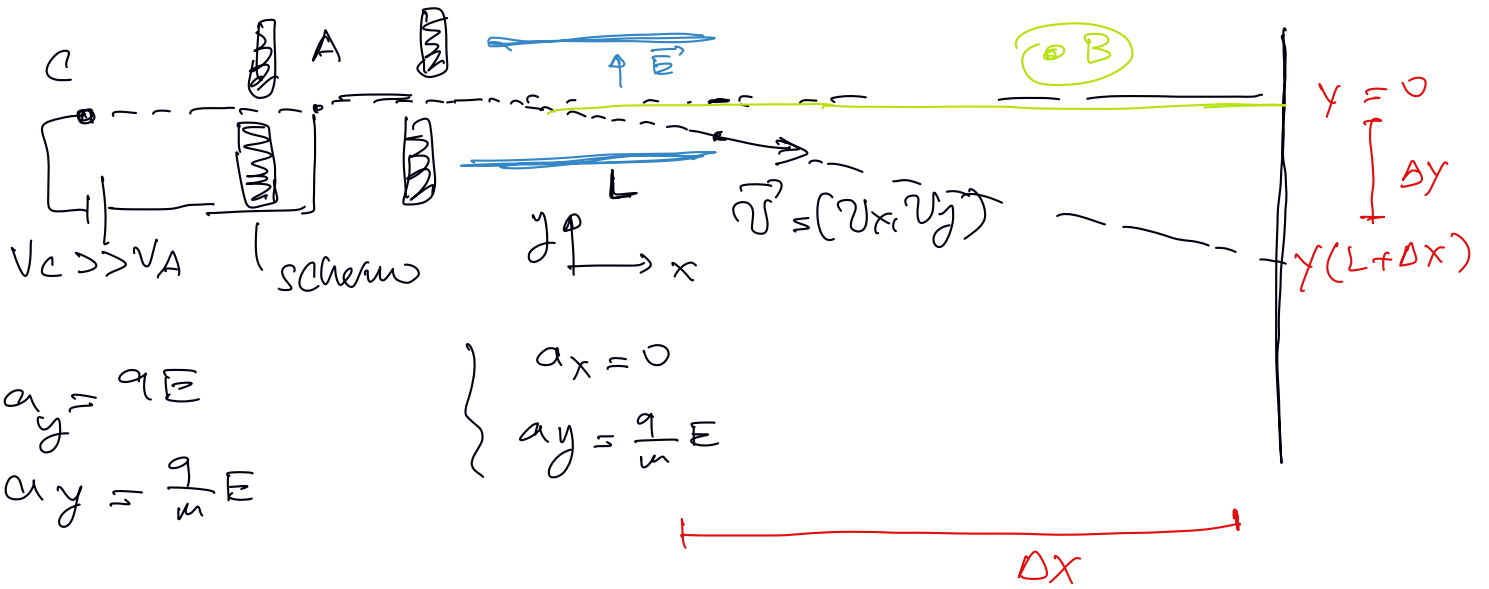
param sotto controllo.

- DV
- tipo di gas
- pressione del gas  $\Rightarrow$  V

variando param  $\Rightarrow$  misurare  $I$

schermo  $\Rightarrow$  non passa corrente.

variazione corrente  $\perp$  con  $\vec{B} \Rightarrow$  particelle cariche.



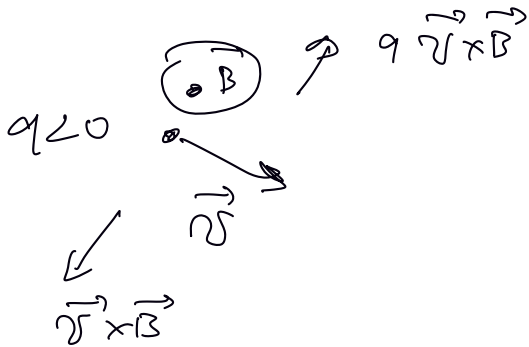
$$m a_y = q E$$

$$a_y = \frac{q}{m} E$$

$$\begin{cases} a_x = 0 \\ a_y = \frac{q}{m} E \end{cases}$$

$$v_y(L) = a_y \cdot \Delta T = \frac{q}{m} E \frac{L}{v_x}$$

$$L = v_x \Delta T \Rightarrow \Delta T = \frac{L}{v_x}$$



$$\vec{F} = q(\vec{v} \times \vec{B} + \vec{E}) = 0$$

$$q(\vec{v} \times \vec{B} + \vec{E}) = 0 \Rightarrow \boxed{v_x = \frac{E}{B}}$$

$$y(L + \Delta x) = \frac{q}{m} E L \frac{B^2}{E^2} \left( \frac{L}{2} + \Delta x \right)$$

determinati dallo spinn.

$\Rightarrow$  stimare  $\frac{q}{m}$  per una configurazione.

Ripetere misure  $\left\{ \begin{array}{l} - \text{diversi gas} \\ - \text{diverse pressioni} \\ - \text{diversi } \Delta V \end{array} \right. \Rightarrow \frac{q}{m} \text{ invariante}$

Thompson:  $\frac{q}{m} = 1.76 \times 10^{11} \text{ C} \cdot \text{Kg}^{-1} \quad q < 0$

$$\vec{F} = m\vec{a} = q(\vec{E} + \vec{v} \times \vec{B})$$

$\Rightarrow$  per poter misurare  $m \Rightarrow$  serve misure indep. di  $q$

Esperimento di Millikan

misura di  $q$

$$m = \frac{4\pi}{3} \rho r^3$$

$\rho$ : densità dell'olio

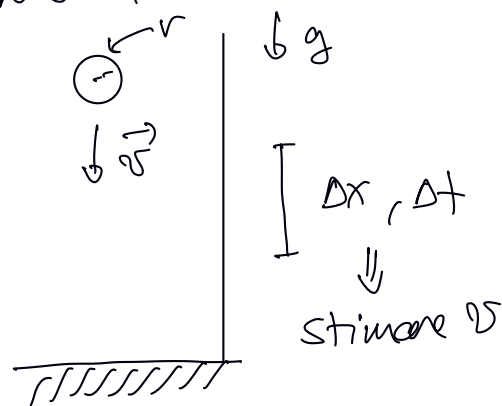
$$F = mg - 6\pi\eta r v_0 = 0$$

$\hookrightarrow$  coeff di viscosità

$v_0$ : vel. limite

$r$ : raggio della sfera.

Nobel 1923



$$\Rightarrow mg = 6\pi\eta r v_0$$

$$\frac{4\pi}{3} \rho r^3 g = 6\pi\eta r v_0$$

$$\Rightarrow r = \sqrt{\frac{9}{2} \frac{\eta v_0}{\rho g}}$$

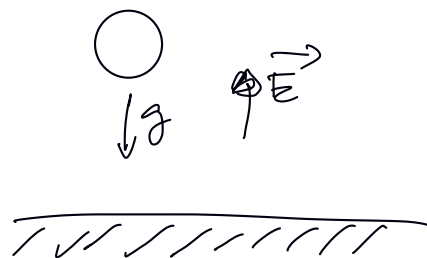
misura di  $v_0 \Rightarrow$  stima di  $r$

Accendo capo elettrico.

(nuova configurazione)

$$F = ma = mg - 6\pi\eta r v_1 - qE = 0$$

$$q = \frac{1}{E} (mg - 6\pi\eta r v_1)$$



$(6\pi r) \rightarrow$  ricevere da  $V_0$  (dalla prima config.

$$6\pi r = \frac{4\pi}{3} \rho g \frac{1}{r_0}$$

$$q = \frac{1}{E} 6\pi r \eta (V_0 - V_i)$$

$\downarrow$   
 $E \approx 0$

$\hookrightarrow E \neq 0$

$\searrow$   
 noto

$\rightarrow$  stimato da  $V_0$ .

misura di  $q \pm 59$

- variazione  $r$
- variazione materiale

Milliken: he visto  $q = \frac{\#}{\text{intero}} e$

$\mathbb{N}$

$$e = 1.59 \times 10^{-19} \text{ C}$$

in accordo  
entro 1%  
con valore  
attuale.

combinando Millikan + Thompson

$$m = 0.911 \times 10^{-30} \text{ kg}$$

$$= 0.511 \text{ MeV}$$

$e^-, p, n, \alpha, \gamma$ , nuclei (ioni)

$$\beta = \frac{p}{E} \quad \beta\gamma = \frac{E}{m}$$

- misure di  $|\vec{p}|$
- misure di  $E$
- misure di  $q$

