Token: 290 631

# OPIS

Decadimento $\beta^{\pm}$

$${}^{A}_{Z}N \rightarrow {}^{A}_{Z+1}N + e^- + \bar{\nu}_e \qquad \beta^-$$

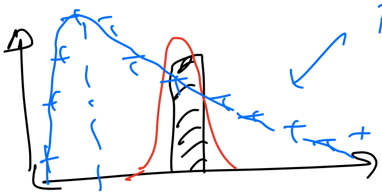
$${}^{A}_{Z}N \rightarrow {}^{A}_{Z-1}N + e^+ + \nu_e \qquad \beta^+$$

$$n \rightarrow p + e^- + \bar{\nu}_e$$

Negli anni 1930' $e^-, p, \gamma,$ nucleo, $\alpha$, $e^+$, $\bar{p}$

Si aspettava la reazione $n \rightarrow p + e^-$

decad. 2 corpi monocrom.




$X \rightarrow Y + e^-$

$$M_X = E_Y + E_e = M_Y + K_Y + M_e + K_e$$

$$Q = M_X - M_Y - m_e = K_Y + K_e$$

$n \rightarrow p + e^-$ $\quad Q = 1\ \text{MeV} - 0.5\ \text{MeV} = 0.5\ \text{MeV}$

$$e^- \longleftarrow \bullet \longrightarrow p$$

$K_Y \neq 0$ trascurabile

Pauli 1930 $\quad n \rightarrow p + e^- + X$

$$\vec{P}_X + \vec{P}_p + \vec{P}_e = \emptyset$$

$$Q = m_n - m_p - m_e - m_X \geq 0$$

$$m_X \lesssim 1\ \text{MeV}$$

$n \to p + e^- + \gamma$

$S \quad \frac{1}{2} \qquad \frac{1}{2} \quad \frac{1}{2}$

$^A_Z N \to {}^A_Z X + e^- + \gamma$

$S \quad A\frac{\hbar}{2} \qquad A\frac{\hbar}{2} \qquad \frac{\hbar}{2}$

- non si vedevano int. di $\gamma$
- non si conservava mom angolare

$\Rightarrow X \neq \gamma$

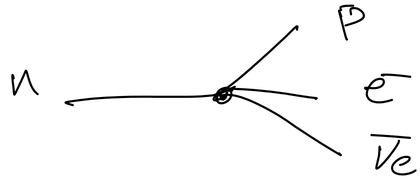
$\Rightarrow$ Ipotesi: esiste particella leggera $s = \frac{1}{2}$ non EM non forte.

Fermi $\Rightarrow$ neutrino.

$e^- + {}^A_{Z+1}N \longrightarrow {}^A_Z N' + \nu_e$

$\Rightarrow$ esistere interazione debole

Teoria di Fermi a 4-fermioni:




$$\Gamma(n \to p + e^- + \bar{\nu}_e) = 2\pi \, |M_{fi}|^2 \rho(E) \big|_{E_f = E_i}$$

$$M_{fi} = -i \int d^3r \, \psi_f^* H_I \psi_I$$

onde piane per particelle iniziali e finali

$$H_I = G \quad \text{costante}$$

$$\psi = \frac{1}{\sqrt{V}} e^{i \vec{p} \cdot \vec{r}} \qquad \vec{p} \text{ impulso della particella.}$$

$$\Gamma(i \to f) : \frac{\text{prob}(i \to f)}{\text{unità di tempo.}} \qquad \Gamma = \frac{1}{\tau}$$

$$[\Gamma] = T^{-1} = E$$

$$\Gamma = 2\pi |M_{fi}|^2 \rho(E)$$

E

$$\int d^3r \, \psi_p^* \psi_e^* \psi_{\nu_e}^* G \psi_n$$

$$V \frac{1}{\sqrt{V}} \frac{1}{\sqrt{V}} \frac{1}{\sqrt{V}} G \frac{1}{\sqrt{V}} = \frac{G}{V}$$

$$[E] = \frac{G^2}{V^2} [\rho]$$

$$\rho(E) = \int \delta(E_f - E_i) \, dn \qquad dn = \frac{V}{(2\pi)^3} 4\pi p^2 dp$$

$$M_{fi} = -i \int d^3r \, \underbrace{\psi_p^* \psi_n}_{\substack{\text{adronica} \\ \text{nucleare}}} \, \underbrace{\psi_e^* \psi_{\nu_e}^*}_{} \, G$$

$n \to p + e^- + \nu_e.$

$$\underbrace{\vec{p}_p + \vec{p}_{e^-} + \vec{p}_\nu}_{} = \emptyset.$$

$$|\vec{p}_p| \simeq \emptyset.$$

$$\psi_e = \frac{e^{i \vec{p} \cdot \vec{r}}}{\sqrt{V}} \qquad \psi_\nu = \frac{e^{i \vec{q} \cdot \vec{r}}}{\sqrt{V}} \qquad \vec{p}_p = -(\vec{p}_e + \vec{p}_\nu)$$

$$\vec{p} \equiv \vec{p}_e \qquad \vec{q} \equiv \vec{p}_\nu \qquad p_p = -(\vec{p}+\vec{q})$$

$$M_{fi} = -iG \int d^3r\, \varphi_p^* \varphi_n \frac{e^{-i(\vec{p}+\vec{q})\cdot\vec{r}}}{\sqrt{V}\sqrt{V}}$$

$$|\vec{p}+\vec{q}| \simeq 1\ \text{MeV} \qquad |\vec{r}| \simeq 1\ \text{fm} = \frac{1}{200\ \text{MeV}}$$

$$(\vec{p}+\vec{q})\cdot\vec{r} \simeq |\vec{p}+\vec{q}|\cdot|\vec{r}| \simeq \frac{1\ \text{MeV}}{200\ \text{MeV}} \sim 5\times10^{-3}$$

$$e^{-i(\vec{p}+\vec{q})\cdot\vec{r}} \simeq 1 + O(\quad)$$

$$M_{fi} = -iG\frac{1}{V}\int d^3r\, \varphi_p^* \varphi_n = -iG\frac{1}{V} N$$

$|N|^2 \sim O(1)$ dai calcoli

$$N = \cancel{V}\int d^3r\, \varphi_p^* \varphi_n$$

$$[N] = \cancel{V}\frac{1}{\sqrt{\cancel{V}}}\frac{1}{\sqrt{\cancel{V}}} = 1$$

$N$ adimensionale

$${}^{A}_{Z}Y \longrightarrow {}^{A}_{Z+1}X + e^- + \nu_e$$

$$N = \underbrace{\int d^3r\, \varphi_X^* \varphi_Y}_{\text{sovrapp. delle funzioni d'onde nucleari}}$$

$$M_{fi} = -i\frac{G}{V}N$$

$$|M_{fi}|^2 = \frac{G^2}{V^2}|N|^2 \quad \propto G^2$$