ipac-2019-U01C04-0409-decaimientos

$$\vec{p} = m\vec{v} \qquad v$$

$$\vec{F} = \frac{d\vec{p}}{dt} \Rightarrow F = \frac{d(mv)}{dt}$$

m es constante $\quad F = m\underbrace{\frac{dv}{dt}}_{a} = ma$

$$\vec{p} = m\vec{v}\gamma$$

$$\vec{F} = \frac{d\vec{p}}{dt} \Rightarrow F = \frac{d(m\vec{v}\gamma)}{dt}$$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \qquad \frac{d\gamma}{dt}$$

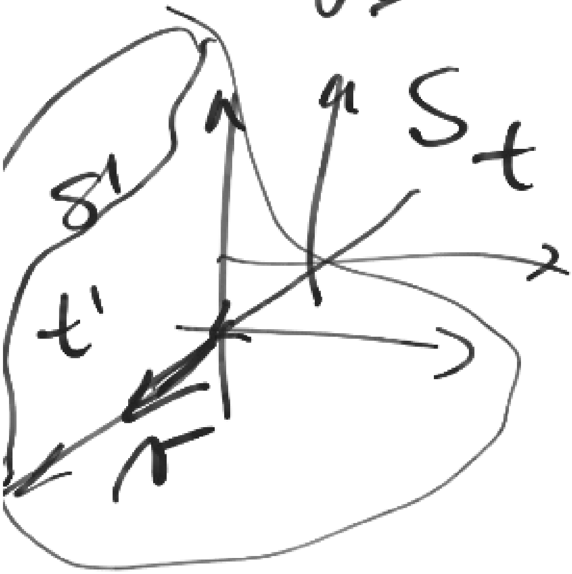
$$F = \cancel{\frac{dm}{dt}v\gamma}^{\,0} + m\underbrace{\frac{dv}{dt}}_{a}\gamma + mv\frac{d\gamma}{dt}$$

Mr Tomkins.

$$\Delta t' = \gamma\,\Delta t \qquad \Delta x = 0$$

$\gamma \cdot 1seg.$ $\quad$ $1seg.$

$\gamma \geq 1 \rightarrow \Delta t'$ „ésmás kutó" Δt



	Δt	$\Delta t'$
$90\% \rightarrow \gamma \simeq 2$	1	2
$95\% \rightarrow \gamma\ 3$	1	3
$100\% - \gamma \rightarrow \infty$	1	∞

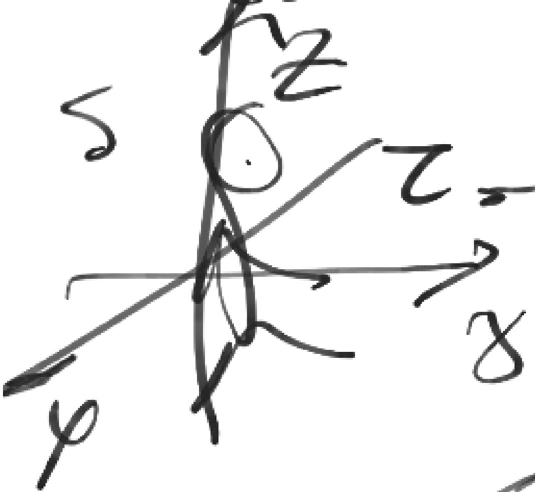
$$\Delta x' = \frac{\Delta x}{\gamma} \qquad \gamma \geq 1$$

$$E = m\gamma c^2$$

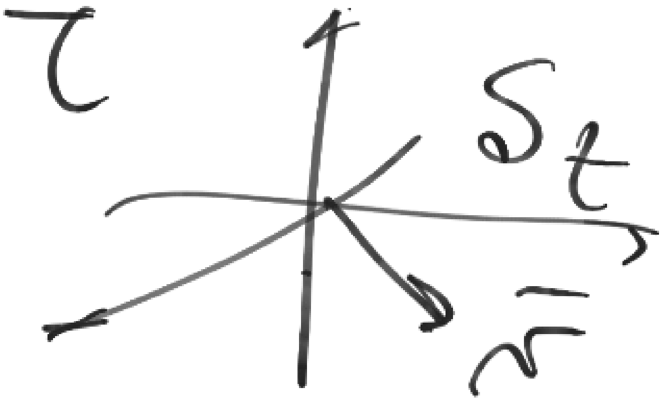
$v \to c \Rightarrow \beta \to 1 \Rightarrow \gamma \to \infty$

$\Rightarrow E \to \infty$

"comovil" → "que se mueve con"

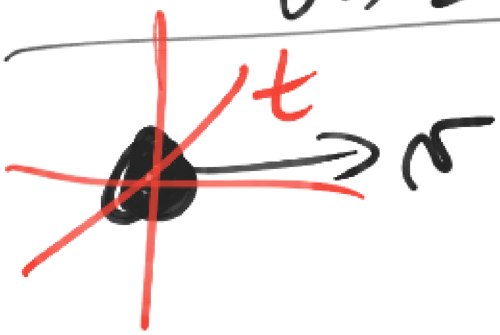


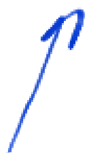
τ = tiempo propio.

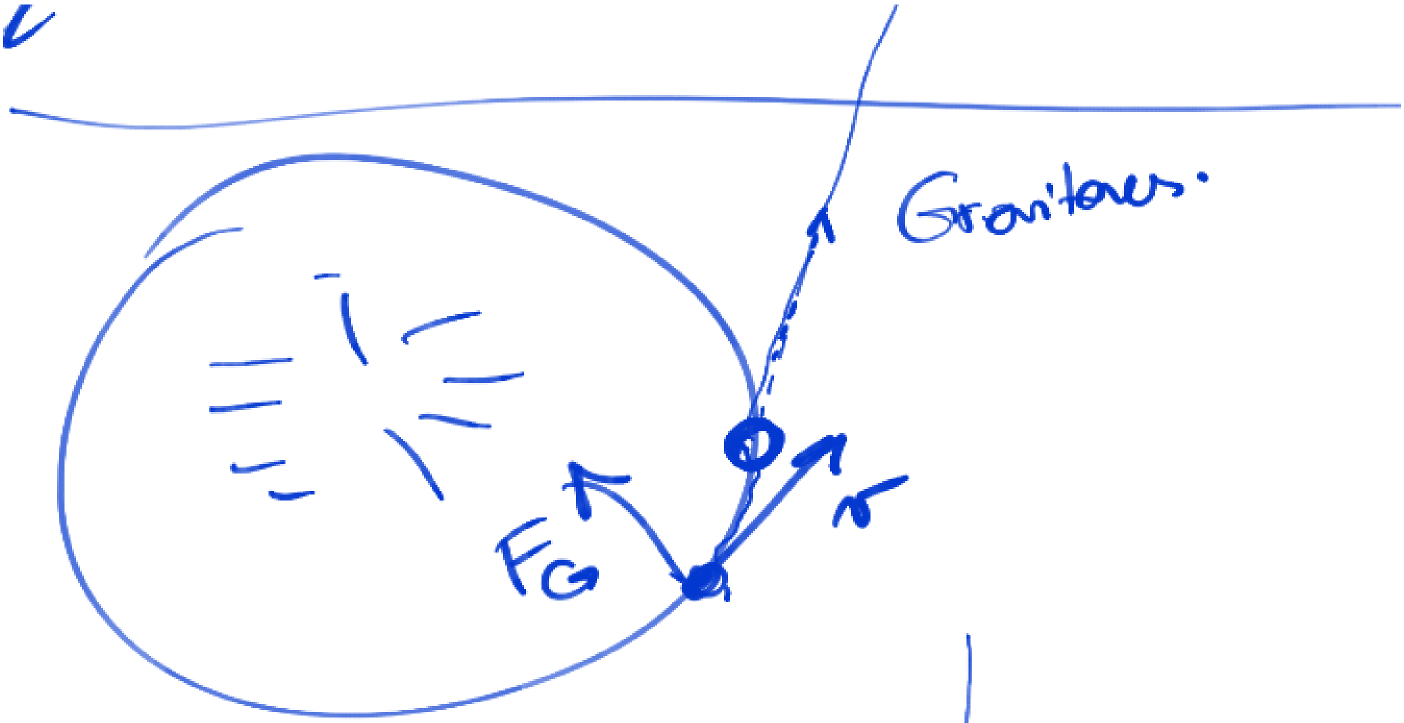


$dt = \gamma d\tau$

$\gamma \geq 1$







$$E_c = \frac{1}{2} m v^2$$

$$E = mc^2 + \frac{1}{2} m v^2 \quad \text{si } v << c$$

$$E = mc^2 \gamma$$

$$mc^2$$

$\rightarrow E = E \ldots + E \ldots$

$\Rightarrow E = E_0 + E_c$

$E_c = (\gamma - 1) mc^2$

$$\underline{E_c = (\gamma - 1) mc^2}$$

$\downarrow$

$\frac{1}{2} m v^2$

$v \ll c$

$\gamma \sim 1$

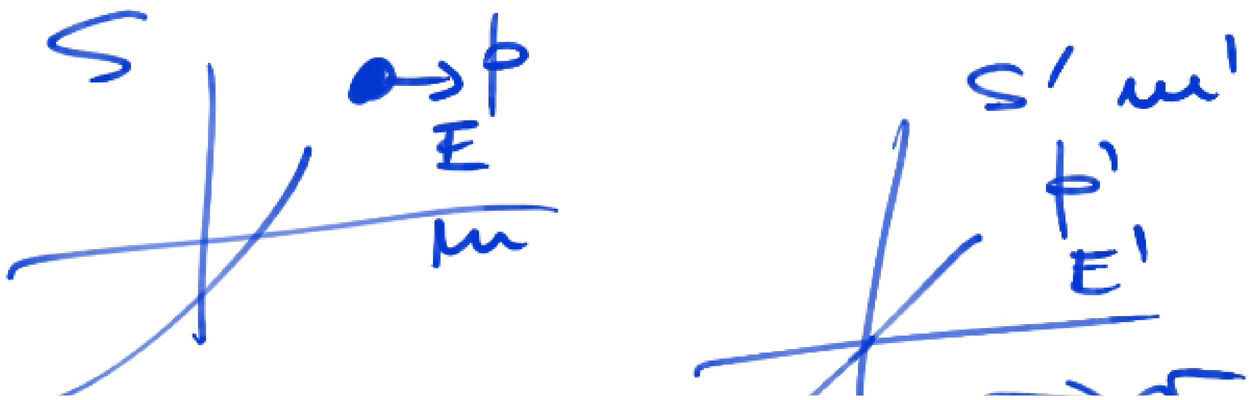
---

m es un invariante relativista.

$$\boxed{E^2 - (pc)^2 = m^2 c^4}$$

$$\boxed{E^2 - (pc)^2 = (mc^2)^2}$$

invariante relativista.



$$\left.\begin{aligned} m &= m' \\ E &\neq E' \\ p &\neq p' \end{aligned}\right\} \quad E^2 - (pc)^2 = E'^2 - (p'c)^2$$

$$\boxed{E^2 - p^2c^2 = m^2c^4 = E'^2 - p'^2c^2}$$

invariante relativista.

m

$$E^2 = m^2c^4 + p^2c^2$$

$$\Rightarrow E = \sqrt{m^2c^4 + p^2c^2} = m\gamma c^2$$

$$v = 0 \Rightarrow p = 0$$

$$E = \sqrt{m^2c^4} = mc^2$$

$$p \gg m$$

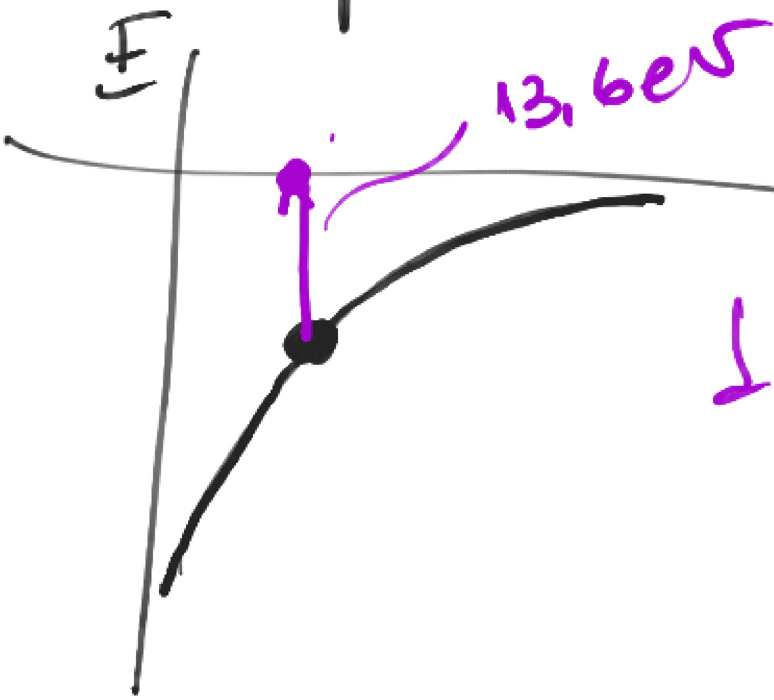
$$E = \sqrt{p^2c^2\left(\sqrt{m^2c^2 \dots} + 1\right)}$$

$$E = \sqrt{p^2 c^2 \left(\frac{m^2 c^2}{p^2} + 1\right)}$$

Si $p \gg m \rightarrow E \rightarrow \sqrt{p^2 c^2}$

Si $p \gg m$ $E \rightarrow pc$

$$E = \pm\sqrt{p^2 c^2 + m^2 c^4}$$



en el Átomo Hidrógeno

$1\ Ry = 13{,}6\ eV$

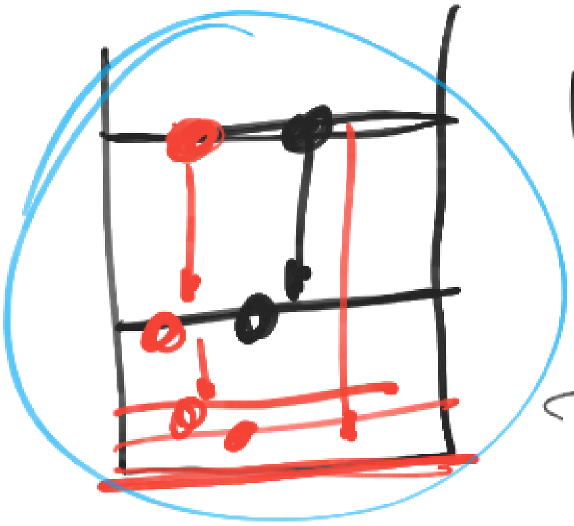
$$E_T = E_p + E_c$$

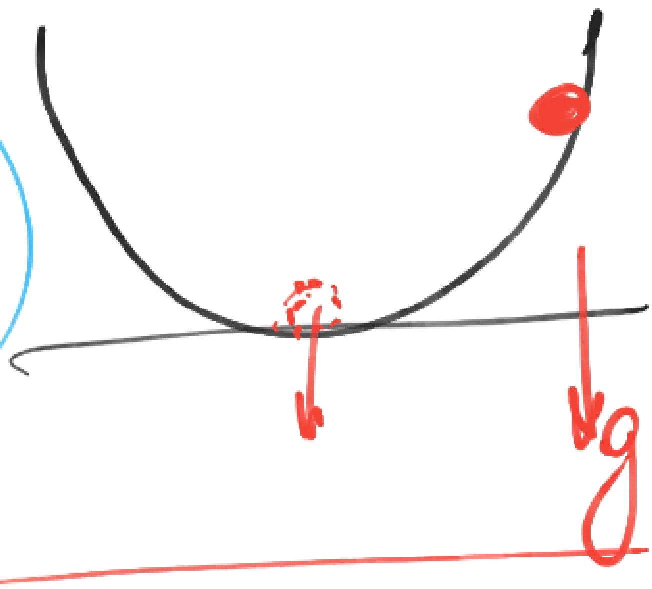
$$E_T = -\frac{GMm}{r^2\ r} + \frac{1}{2} m v_0^2$$

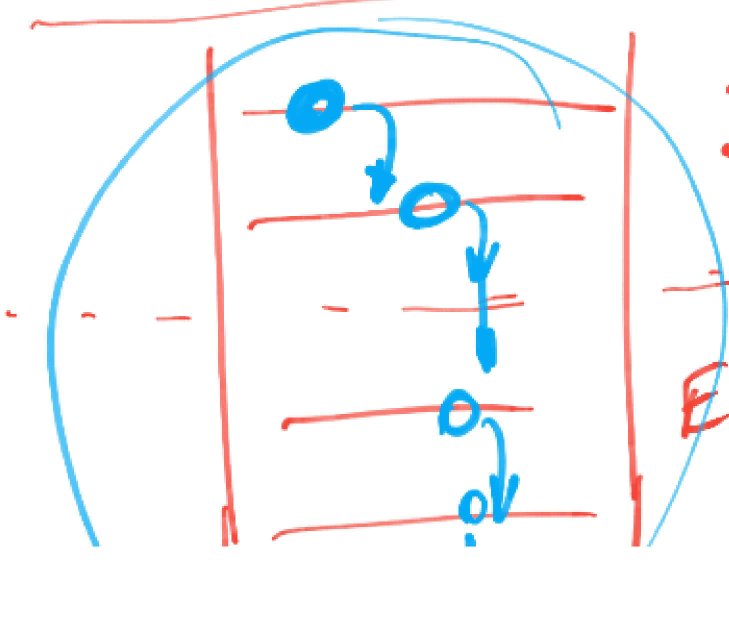
$$\boxed{E_T = -\frac{GMm}{2r^2}}$$ en un est orbital

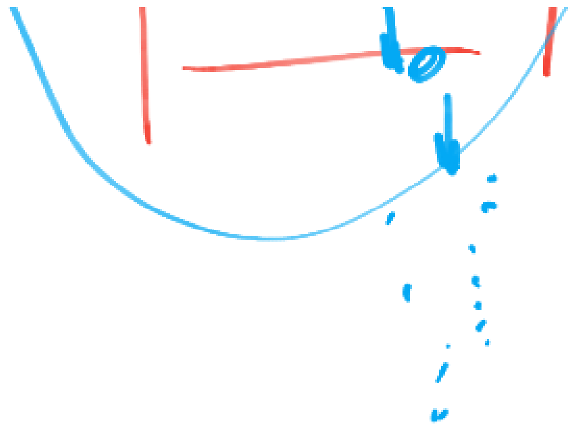
$$E = mc^2\gamma \geq 0$$

$$E = \pm\sqrt{p^2c^2 + m^2c^4}$$









problema relativo

Dirac 1928.

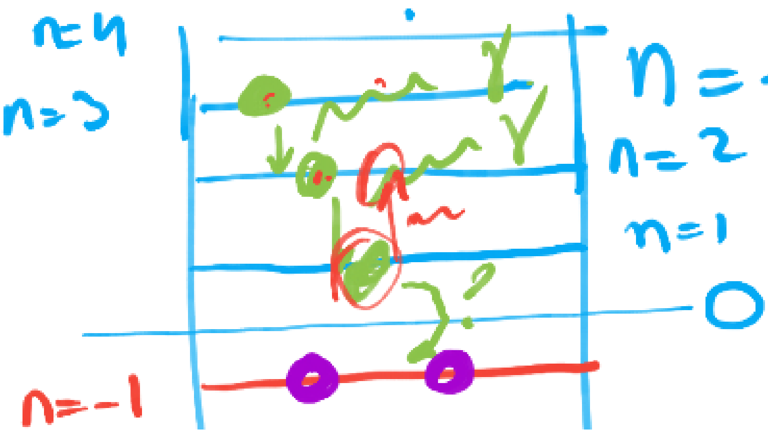
$$(i\not\partial - m)\psi = 0$$

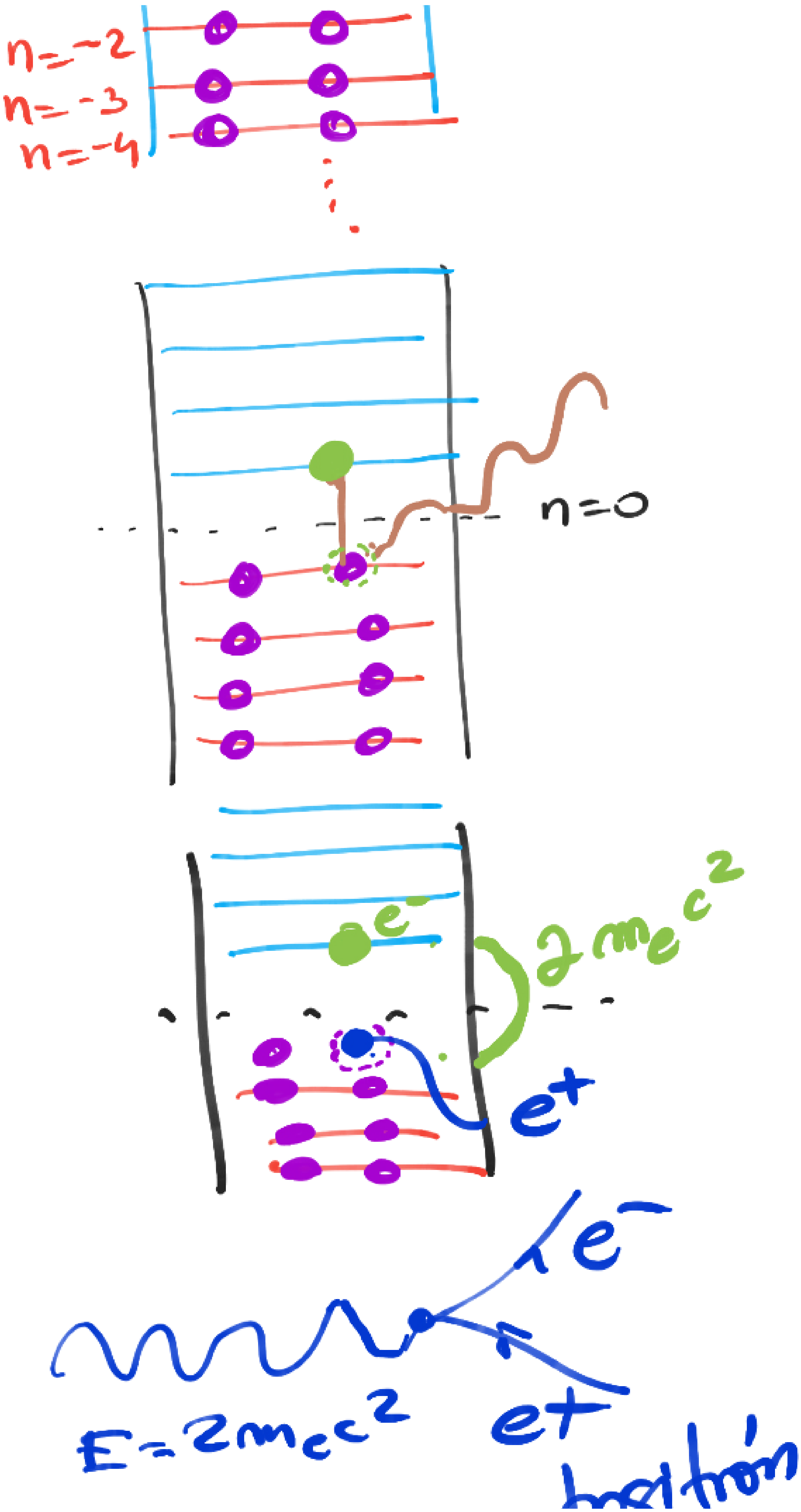
$$\not\partial = \gamma^\mu\partial_\mu \qquad \sum_{\mu=0}^{3}\gamma^\mu\partial_\mu$$

$$(i\not\partial - m)\psi = 0 \qquad (4\times4)$$

$E_n \propto n^2$ $\quad n = 1, 2, 3, \ldots$

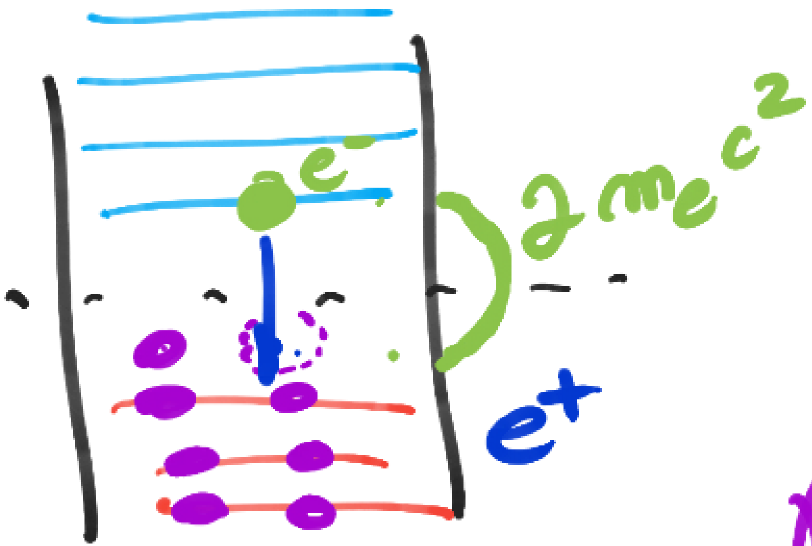
$n = -1, -2, -3, -4 \ldots$

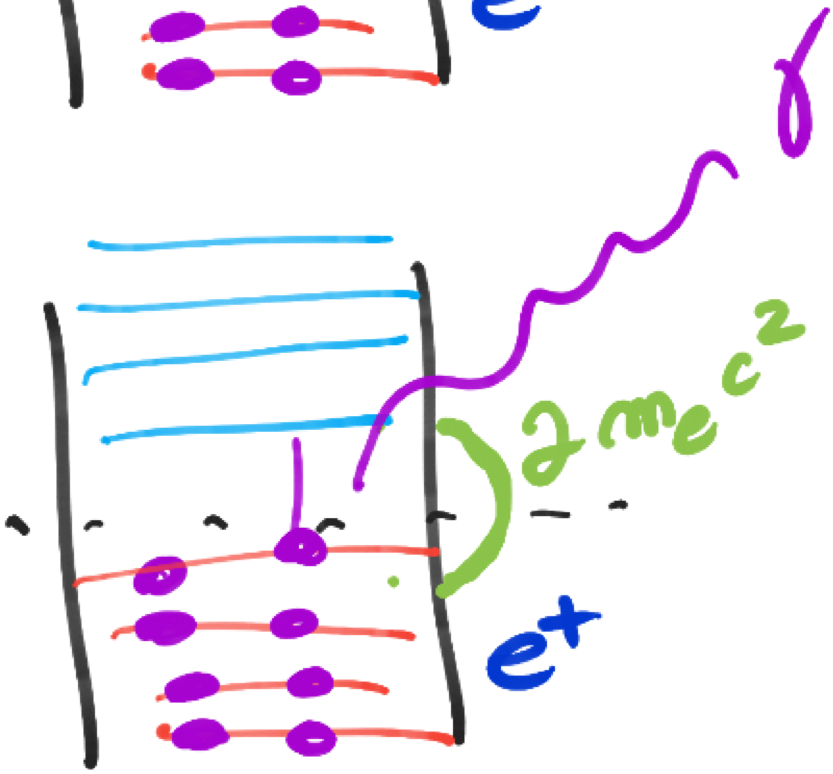



n=-2
n=-3
n=-4
n=0
e⁻
2mₑc²
e⁺
e⁻
E=2mₑc²
e⁺
positrón

electrón → positrón e^+

electrón → negatrón e^-

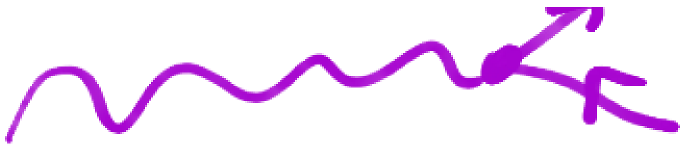




$$E_\gamma = E_f - E_i = 2m_ec^2$$

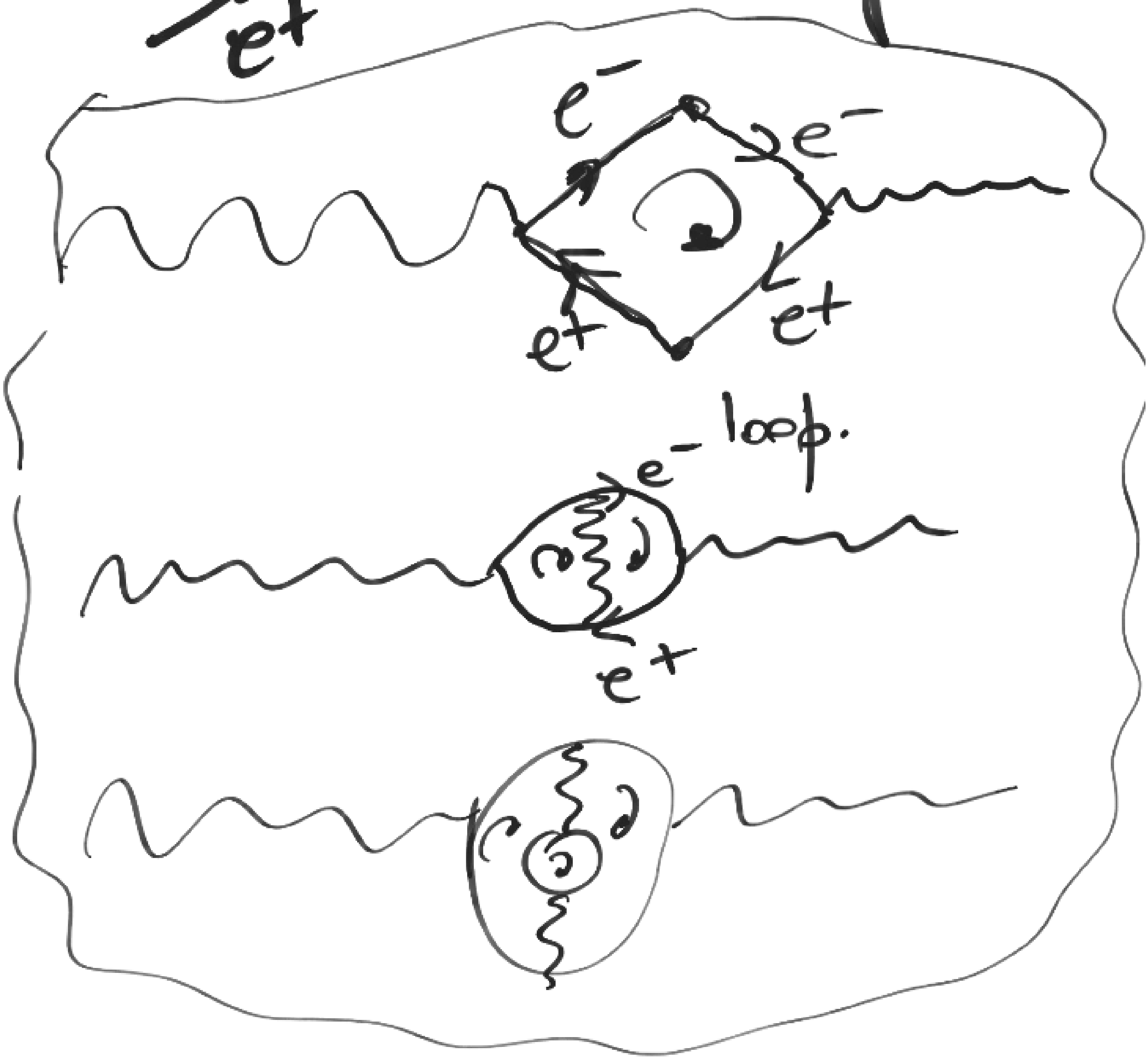
$$E_\gamma = 1{,}022 \text{ MeV}$$

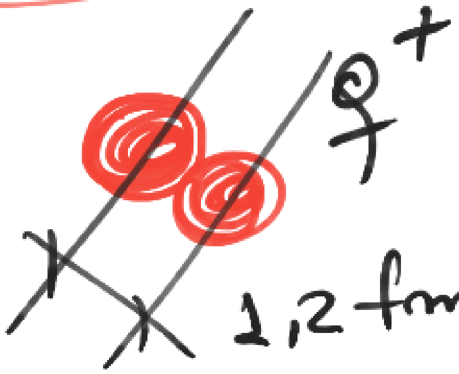
e^-



$E_\gamma \geq 1022$ keV e^+ Creación de pares.

$E_\gamma = 1022$ keV Aniquilación de pares.





$1{,}2\,\text{fm} \simeq 1{,}2 \times 10^{-15}\,\text{m}$

$$F_E = \frac{k_c\, e^2}{r^2}$$

$$F_G = \frac{G\, m_p^2}{r^2}$$

$$\frac{F_E}{F_G} = \frac{k_c\, e^2 / \cancel{r^2}}{G\, m_p^2 / \cancel{r^2}}$$

$$= \frac{k_c}{G}\left(\frac{e}{m}\right)^2 \simeq 10^{36}$$

$m_p \simeq m_n$ $\qquad m_p = 938{,}3 \ MeV/c^2$

uma $\qquad m_n = 939{,}6 \ MeV/c^2$

p  $\qquad m = 1 \qquad 1{,}008$

Fuerza Fuerte.

Z → Número Atómico

N → cantidad de Neutrones

$A = (Z+N)$ → Número Másico

N

Fuerza fuerte.

$z = 82$

$N = 126$

$^{208}_{126}Pb_{82}$

Algunos núcleos emitían electrones

rayos β

Bismuto → Polonio

$$^{210}_{127}Bi_{83} \longrightarrow {}^{210}_{126}Po_{84} + e^-$$

$$n^0 \longrightarrow p^+ + e^-$$

A

N   Z

$N = A - Z$

fuerza débil

210 - Bi

$Z = 83$

$A = 210$

$N = 127$

$$^{210}_{127}Bi_{83} \longrightarrow {}^{210}_{126}Po_{84} + e^-$$

E_T $\qquad\qquad$ E_T

$$E_i = m_i \gamma c^2 \qquad\qquad E_f = \sum m_{Po}\gamma c^2_{Po} + m_e \gamma_e c^2$$

$\gamma = 1$

$$m_{Bi}c^2 = m_{Po}c^2 + m_e \gamma_e c^2 + Q$$

$\gamma_e \simeq 1$

$$m_{Bi}c^2 \simeq m_{Po}c^2 + m_e c^2 + \underbrace{(\gamma_e - 1) m_e c^2}_{E_c}$$

Ec del electrón

$$E_c = m_{Bi}c^2 - m_{Po}c^2 - m_e c^2$$

$$E_c = \underbrace{(m_{Bi} - m_{Po} - m_e)c^2}_{<0}$$

<0 No puede ocurrir.

$$m_{Bi}c^2 = m_{Po}c^2 + m_e c^2 + \underline{E_c}$$

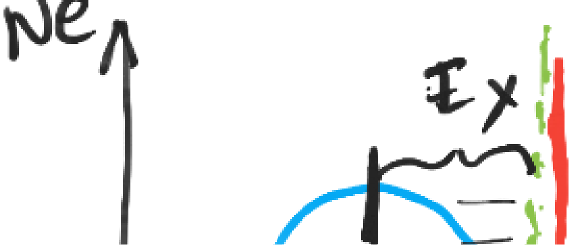
$$E_c = (m_{Bi} - m_{Po} - m_e)c^2$$

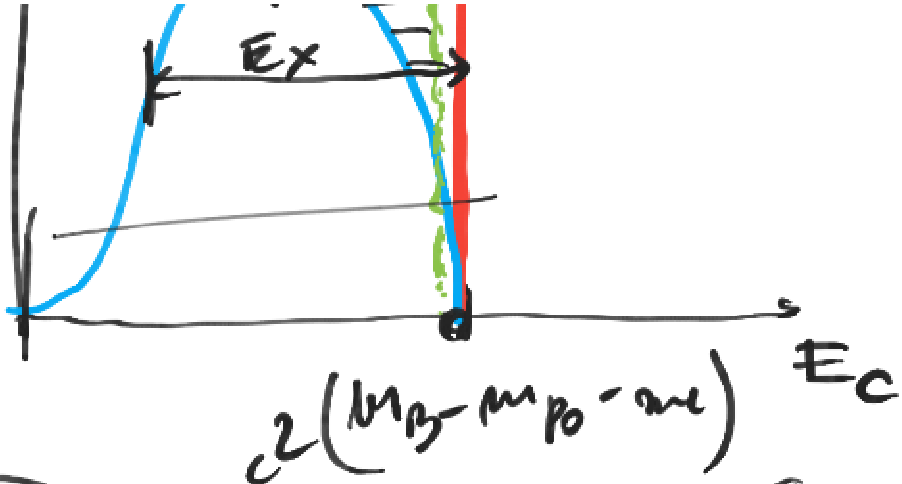
<0 No ocurre. X

$=0$ ocurrir. X

>0 ocurre.

Ec del electrón emitido siempre es igual





$$\boxed{n^0 \to p^+ + e^- + \bar{\nu}_e^0}$$

neutrino

$p \quad \bar{p} \qquad \mu \quad \bar{\mu} \qquad e \quad \bar{e}$

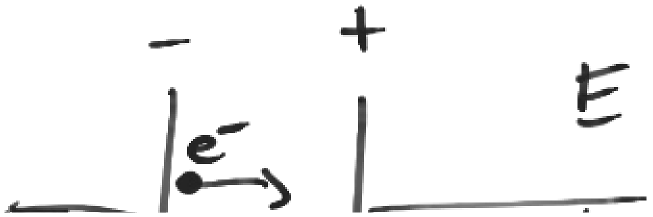
$\nu \quad \bar{\nu}$

$$E = m_e \gamma c^2$$

e^-

$$E_T = m_e c^2 + E_c$$

$$(m_{Bi} - m_{Po} - m_e)c^2 = 1{,}16 \text{ MeV}$$



$$E = qV$$

$(1e)(1V)$

1V

$= 1\,eV$

$E = 1{,}602 \times 10^{-19}\,J$

$1\,MeV = 10^6\,eV = 10^6 \times 1{,}602 \times 10^{-19}\,J$

$= 1{,}602 \times 10^{-13}\,J$

$Q = 1{,}16\,MeV.$

$E_T = m_e c^2 + 1{,}16\,MeV.$

$= 0{,}511\,\frac{MeV}{\cancel{c^2}} \cdot \cancel{c^2} + 1{,}16\,MeV$

$E_T = 1{,}671\,MeV = m \gamma c^2$

$\gamma = E_T / m_e c^2$

$= \dfrac{1{,}671\,M\cancel{eV}}{0{,}511\,M\cancel{eV}\,\cancel{c^2}} \Rightarrow \gamma = 3{,}27$

$0{,}511 \frac{MeV}{c^2} \cdot 4$

$\gamma = 3{,}27$

$\beta = 0{,}5$
$\gamma = 1{,}15$

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} \Rightarrow \gamma^2 = \frac{1}{1-\beta^2}$$

$$\beta^2 = 1 - \gamma^{-2} \Rightarrow \beta = \sqrt{1 - 1/\gamma^2}$$

$$\beta = 0{,}952 \quad \boxed{v_e = 0{,}952 \cdot c}$$