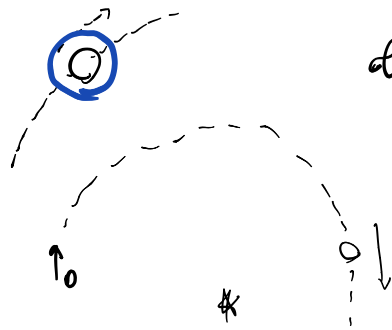
Velocità della luce finita

Romer e la luna di Giove "Io"

$v_\oplus \sim 10^{-2} c$

$v_\odot \sim 10^{-3} c$

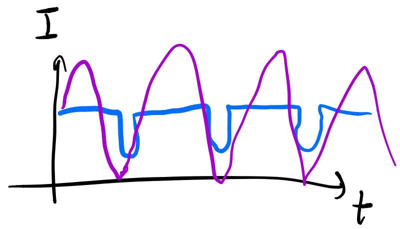



altri sistemi di satelliti danno la stessa c

$\Rightarrow c < \infty$ e non dipende dalla vel. rel. tra sorgente e osservatore

$\tau_{zw} = 3 - 15$ min $\quad \tau_{zw} = 3 + 15$ min

stelle binarie

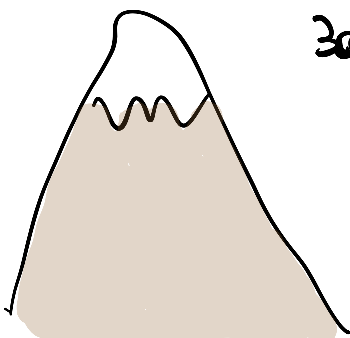



c non dipende da $v_{sorgente}$

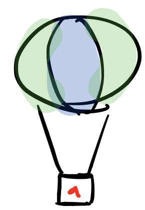
Michelson & Morely $\quad c \cong 30$ cm/ns

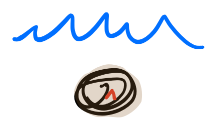
$\mu$  $\xrightarrow[1\mu s]{}$  $e$

$$d = 1000 \cdot 30 \text{ cm} = 300 \text{ m} \left(\frac{v}{c}\right)$$



3000 m — $N_{3000}$

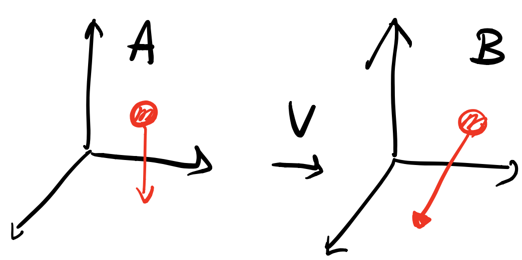




~ 100-300 m — $N_0 \simeq N_{3000}$

$v = c$ è un fatto assoluto

$$v'_B = v_A + V$$



$$x' = [x + Vt]\,\gamma(V)$$

$$\Downarrow$$

$$\Delta x' = (\Delta x + V\Delta t)\,\gamma(V)$$

$$v' = \frac{\Delta x'}{\Delta t'} = \left(\frac{\Delta x}{\Delta t'} + V\,\frac{\Delta t}{\Delta t'}\right)\gamma(V)$$

$\Delta t = \Delta t'$ (tempo universale)

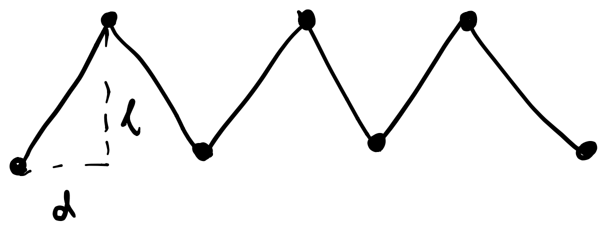
$$v' = (v + V)\,\gamma(V) \qquad \gamma(V) = \frac{1}{1 + V/c}$$

OROLOGIO A FOTONI

$$v = 0$$

$$t_0 = 2\,l/c$$

$$l = c\,t_0$$



$$D = \sqrt{l^2 + d^2} \qquad t = D/c$$

$$t^2 = \frac{l^2 + d^2}{c^2} = t_0^2 + \frac{d^2}{c^2} = t_0^2 + \left(\frac{v}{c}t\right)^2$$

$$t_0^2 = t^2 - \frac{v^2}{c^2}t^2$$

$$t_0 = t\left(1-\beta^2\right)^{1/2} = t/\gamma$$

$$\Delta t' = \Delta t_0 \left(1-\beta^2\right)^{-1/2} \qquad t' = \left(t - \beta\frac{x}{c}\right)\gamma$$

IL TEMPO NON È ASSOLUTO

$[x] = [\beta \cdot tc]$ $\qquad \beta = \frac{v}{c} <<< 1$

$[t] = [\beta \frac{x}{c}]$

$$\begin{cases} x' = \dfrac{x - \beta tc}{\sqrt{1-\beta^2}} \simeq (x - \beta tc)\left(1 + \frac{1}{2}\beta^2 + \dots\right) \\[2ex] t' = \dfrac{t - \beta \frac{x}{c}}{\sqrt{1-\beta^2}} \end{cases}$$


$$x^2 + y^2 = x'^2 + y'^2$$

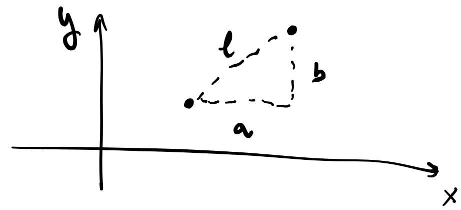
$$c^2 t'^2 - x'^2 = c^2 \frac{t^2 - 2\beta \frac{x}{c} t + \beta^2 \frac{x^2}{c^2}}{1-\beta^2} - \frac{x^2 - 2\beta x tc + \beta^2 t^2 c^2}{1-\beta^2}$$

$$= \frac{c^2 t^2 (1-\beta^2) - x^2 (1-\beta^2) - 2\beta c(\cancel{xt} - \cancel{xt})}{1-\beta^2}$$

$$= c^2 t^2 - x^2$$

$$c^2 t'^2 - x'^2 = c^2 t^2 - x^2$$

$\ell = \sqrt{a^2+b^2}$

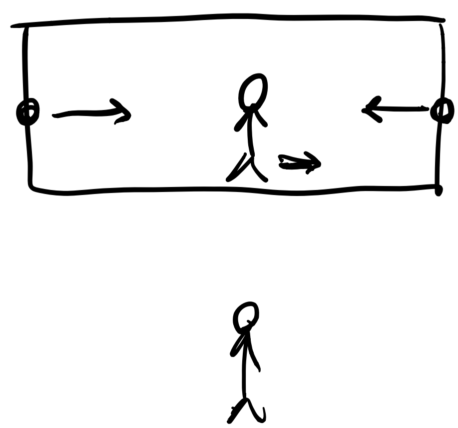



$s^2 = a^2 - b^2$

$s^2 = t^2 - x^2 = t'^2 - x'^2 = s'^2$

intervallo

SIMULTANEITÀ



$\Delta t^{treno} = 0$

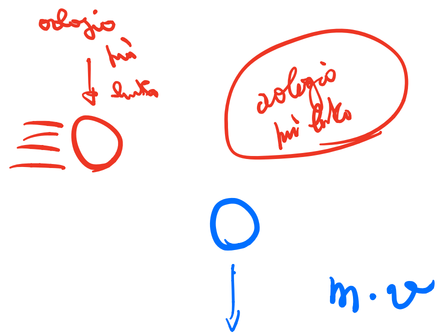
$\Delta t \gtrless 0$ dalla piattaforma

$$x'^{\mu} = (t', x') = \Lambda x^{\mu}$$

$$\partial_\mu = \frac{d}{dx^\mu} \sim \Lambda^{-1} \qquad i\partial_\mu = P_\mu = (E, p_x)$$

Contrazione dei tempi → aumento delle energie

contrazione delle lunghezze → aumento delle q.tà di moto




$$\gamma m \cdot v \left(\frac{1}{\gamma}\right) = p$$

poiché $mv = mv$ in ciascun sistema di riferimento in cui $m = m$, $v$ dell'altro deve risultare minore a causa della dilatazione dei tempi. $1/\gamma$ $\quad v' = v/\gamma$

Se $m \cdot v = m'v'$ per conservare la q.tà di moto allora si deve aumentare $m$ in $m' = m\gamma$

$$m\gamma = m \frac{1}{\sqrt{1-\beta^2}} = m_0\left(1 + \frac{1}{2}\beta^2\right)$$

$$mc^2 = m_0 c^2 + \underbrace{\frac{1}{2} m_0 v^2}_{E_{cin}}$$

$$E_{tot} = E_{riposo} + E_{cin} = m_0 \gamma c^2$$