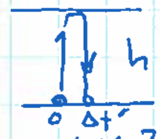
L28

Time dilation:

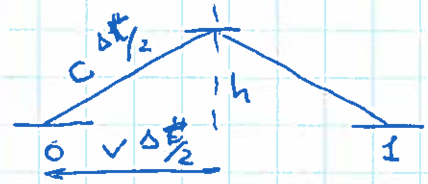
inside moving train

S' frame (v)



on the ground

S frame



$\Delta t'$ - proper time interval

round-trip time $\Delta t' = \frac{2h}{c}$

$$\Delta t = \frac{2h}{c}\frac{1}{\sqrt{1-v^2/c^2}} = \gamma \Delta t'$$

* time dilation in 1h. flight: (1971)

$$\Delta t = \frac{\Delta t'}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1h}{\sqrt{1-10^{-12}}} = 1_h \cdot \left(1 \pm \tfrac{1}{2}\cdot 10^{-12}\right) = 3600_s + 1.8\cdot 10^{-8}\,s$$

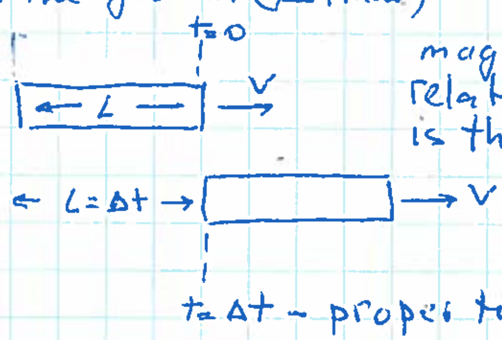
(1971 experiment with atomic clocks)

* live time of a muon. produced in cosmic Rays.

Rossi & Hall (1941)

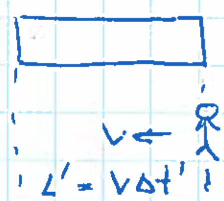
Lenght Contraction

on the ground (S frame)



magnitude of relative velocity is the same for S & S' fr.

inside moving train (S' frame)



Δt is measured in S frame.

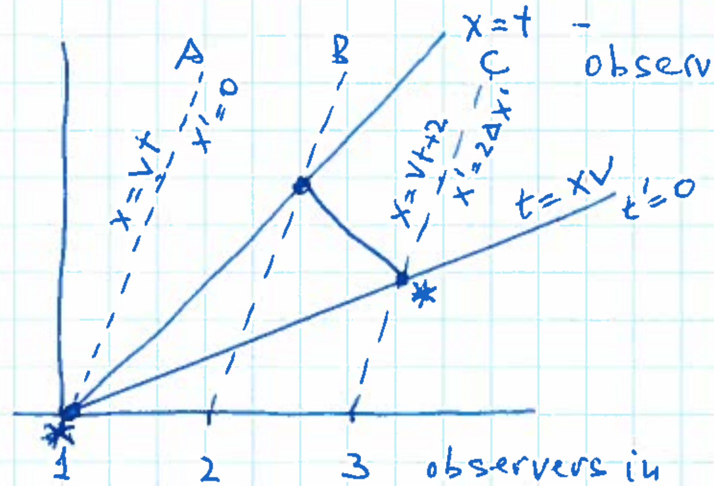
$\Delta t'$ is measured in S' frame

$$l'/l = \Delta t'/\Delta t = \gamma$$

So $\quad l = \frac{l'}{\gamma} = \frac{l_0}{\gamma}$ $\quad l_0$ - proper length in rest frame

$l < l_0$ — length contraction.

L28 Lorentz Transformation.



- observers in movig frame S'

* – simultaneous events in S' frame, but they are not simultaneous in S frame.

observers in S frame.

$S \to S'$

$x' = (x - vt) f(v)$

$t' = (t - xv) g(v)$

for a light ray

$x' = t'$

$x = t$ $\to$ $x' = x(1-v)f$, $t' = t(1-v)g$ $\quad f = g$

same transformation for $S' \to S$, only $v \to -v$

$x = (x' + vt')f$ $\quad$ substitute x' & t'

$t = (t' + vx')f$ $\quad$ $x = (x - vt)f^2 + v(t - vx)f^2 =$

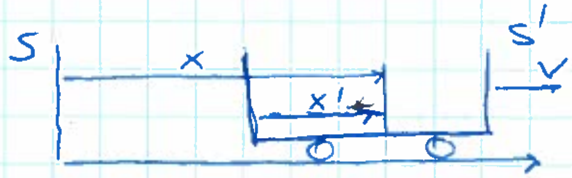
$= xf^2 - v^2 x f^2 - \cancel{vtf^2} + \cancel{vtf^2} = x \to f^2 = \frac{1}{1 - v^2} = \gamma^2$

$f = \frac{1}{\sqrt{1 - v^2}}$ $\quad$ return back c: $vx \to vx/c^2$, $v \to v/c$

$y' = y$ $\quad x' = \gamma(x - vt)$

$z' = z$ $\quad t' = \gamma\left(t - \frac{vx}{c^2}\right)$ $\quad \to$ Lorentz transform

* another derivation:



$x - vt = \frac{x'}{\gamma}$ ← proper length

or $x' = \gamma(x - vt)$

$x = \gamma(x' + vt')$ ← reverse $v \to -v$

$\Big\}$ $t' = \gamma\left(t - \frac{xv}{c^2}\right)$