Compare: $\dfrac{|x_B - x_A|}{(t_B - t_A)}$ to .. $\underline{\underline{c}}$!

$$\frac{|x_B - x_A|}{t_B - t_A} > c,$$ then,

A cannot influence B

There exists a frame where:

A & B are <u>simultaneous</u>, but physically separated.

$\boxed{\text{SPACE-LIKE}}$

$$\frac{|x_B - x_A|}{t_B - t_A} < c$$

A can influence B

No frame where A & B simultaneous, but, a frame where $x_A' = x_B'$ with $\Delta t' = t_B' - t_A'$ $\boxed{\text{TIME-LIKE}}$

C

Look in a different frame

Define! $L = \cancel{\Delta x} = x_B - x_A > \underline{0}$ assume

$T = \cancel{\Delta t} = t_B - t_A$

$x_A' = \gamma(x_A - u t_A)$ $\quad x_B' = \gamma(x_B - u t_B)$

$t_A' = \gamma(t_A - \frac{u}{c}\frac{x_A}{c})$ $\quad t_B' = \gamma(t_B - \frac{u}{c}\frac{x_B}{c}$

$L' = \gamma(x_A - x_B - u(t_B - t_A)) = \gamma(\Delta x - u\Delta t)$

$L' = \gamma(L - uT)$

$T' = \gamma(T - \frac{u}{c}\frac{L}{c})$ stare.

$\Delta t - \frac{u}{c}\frac{\Delta x}{c}$

$u < c$

so if $\boxed{L > cT}$ then $\frac{L}{c}$ $L'$ can never change sign. "space like"

Is: $L'$
A) always $> 0$
B) always $= 0$
C) always $< 0$
D) none of above

$T'$? $T - \beta \cdot \frac{L}{c}$ ^ big

$T'$ can be ... $> 0$ $\quad \beta$ super small

$= 0$ $\quad \beta$ just right

$< 0$

d

Event A : $x_A = 0$, $t_A = 0$

Event B : $x_B = 20\,ft$, $t_B = 40\,ns$

(A) SPACE-LIKE

(B) TIME-LIKE

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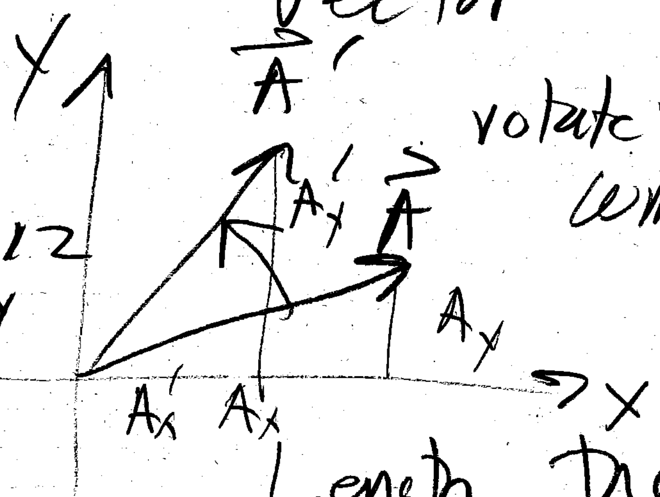
Consider the "Interval"

Lorentz Invariant

Analogy: Length of a Vector

$A_x^2 + A_y^2 = A_x'^2 + A_y'^2$




rotate: compone

Length the same.

[redacted]

$$L < cT$$

now $T' = \gamma\left(T - \frac{v}{c}\frac{L}{c}\right) > 0$ no matter what!

$\frac{v}{c} < 1$

TIME-LIKE

$$L' = \gamma(L - vT)$$

$> 0$
$= 0$
$< 0$

choose $v = \frac{L}{T}$

$$\underline{\underline{L' = 0}}$$

Events on TOP of each other.

but

$$T' = \frac{1}{\sqrt{1 - \frac{1}{c^2}\frac{L^2}{T^2}}}\left(T - \frac{L^2}{c^2 T}\right)$$

$$= T\sqrt{1 - \frac{L^2}{c^2T^2}} = \sqrt{T^2 - \left(\frac{L}{c}\right)^2}$$

big small

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when $L > cT$, a frame where two events simultaneous exists.

$$T' = 0 = \gamma\left(T - \frac{v}{c}\frac{L}{c}\right)$$

$$T = \frac{v}{c}\frac{L}{c}$$

$$v = \frac{c^2 T}{L}, \quad \beta = \frac{v}{c} = \frac{cT}{L}$$

then

$$L' = \frac{1}{\sqrt{1-\left(\frac{cT}{L}\right)^2}}\left(L - \frac{c^2T^2}{L}\right)$$

$$L' = L \cdot \sqrt{1-\left(\frac{cT}{L}\right)^2} = \sqrt{L^2 - (cT)^2}$$

---

in this frame $\quad \bullet \longleftarrow L' \longrightarrow \bullet$

$t_A' \qquad t_B' \qquad t_A' = t_B'$

obvious $A$ + $B$ cannot influence one another!