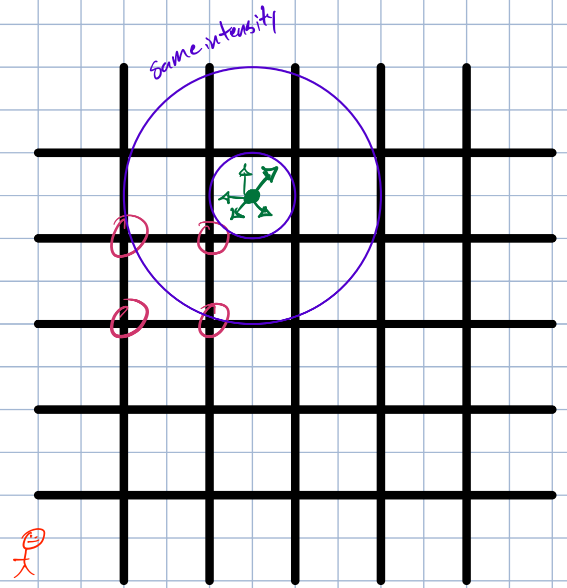
Frame of reference

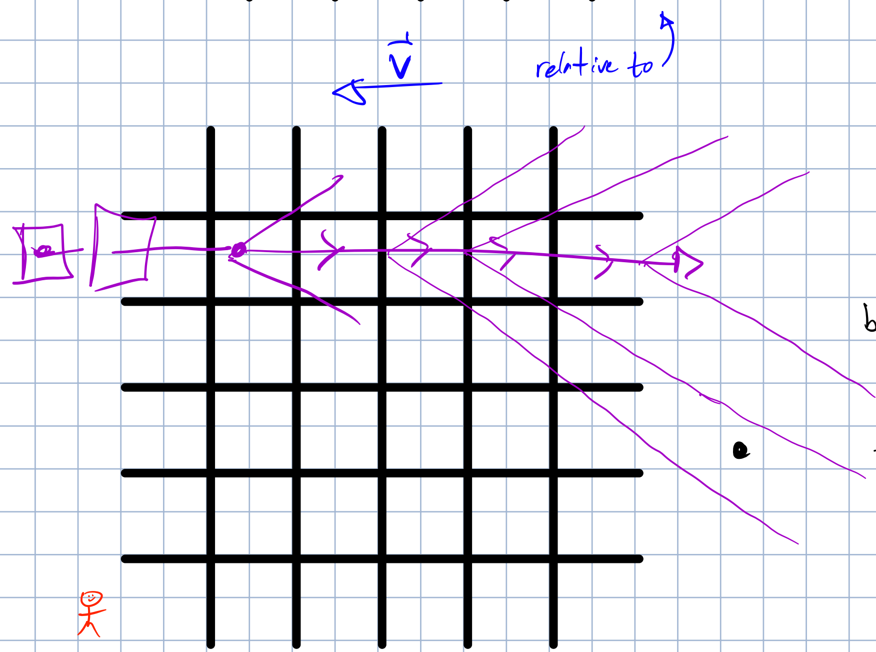
rigid rods / detectors

synchronized clocks



yellow dot!

is it isotropic emitter?
lmao shut up
noway to see



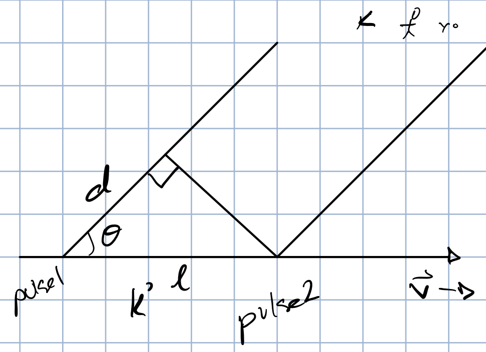
blue light getting brighter

— no longer see it

* looks like moving to right

Doppler Shift

classical effect



moving emitter

k - my frame of reference
k' - emmiters frame of reference

time for emitter move from 1 to 2 : $\Delta t = \left(\frac{2\pi}{\omega'}\right)\gamma$

$$\ell = v \cdot \Delta t$$
$$\phi = v \cdot \Delta t \cos\theta$$

difference in arrival time (in k) $\Delta t_a = \Delta t - \frac{d}{c}$
$= \Delta t\left(1 - \frac{v}{c}\cos\theta\right)$

$$\omega = \frac{2\pi}{\Delta t_a} = \frac{\omega'}{\gamma\left(1 - \frac{v}{c}\cos\theta\right)}$$

4 vectors! :)

general way to manipulate objects that behave like "events" relative to Lorentz transformations

define Minkowski metric : $\eta_{\mu\nu} = \eta^{\mu\nu} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix}$

contravariant: $x^\mu = ct, x, y, z$ "0th" element is time component
covariant : $x_\mu = -ct, x, y, z$

what's a metric?

Pythagorean thm : $ds^2 = dx^2 + dy^2 + dz^2$ OG $(dx\,dy\,dz)\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}\begin{pmatrix} dx \\ dy \\ dz \end{pmatrix}$

on sphere: $ds^2 = (dr)^2 + (r\,d\theta)^2 + (r\sin\theta\,d\phi)^2$

map pairs of vectors to $\mathbb{R}$

geometry of vector space

assign scalar to vector

$$x^\mu x_\mu = x^\mu x^\nu \eta_{\mu\nu} = |\vec{x}|^2 - (ct)^2 = s^2$$

sum over upper & lower index

here, length can be negative

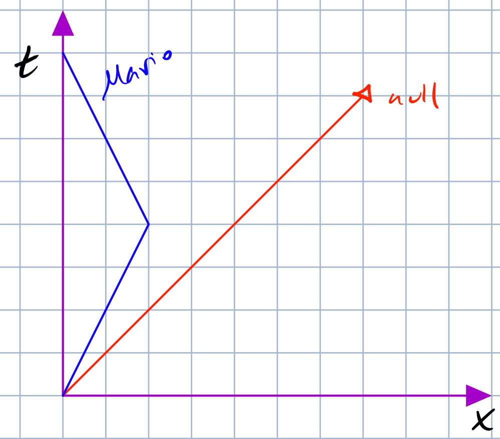
Minkowski method is not semi definite

positive length - spacelike

0 length - lightlike, null

negative length - time like

$d\tau$ proper time $\quad c^2 d\tau^2 = c^2 dt^2 - |d\vec{x}|^2$



$x = \cosh(\tau)$
$t = \sinh(\tau)$