Energy density u

$\left(\frac{J}{m^3}\right)$

ideal nonrel. gas: $P = \frac{2}{3}u$

photon (ultrarelativistic) gas: $P = \frac{1}{3}u$

ISS: $V = 7660\ \frac{m}{s}$

≈ 25 ppm of c

clock on ISS: goes 0.33 ppb slower than stationary

$$\boxed{\gamma = \frac{1}{\sqrt{1-v^2/c^2}}}$$

$$= 1 + \underbrace{\frac{\partial \frac{1}{\sqrt{1-v^2/c^2}}}{\partial \frac{v^2}{c^2}}}_{\frac{1}{2}}\left(\frac{v^2}{c^2}\right)$$

$$\left(1-v^2/c^2\right)^{-1/2}$$

$$-\frac{1}{2}(\quad)^{-\frac{3}{2}}(-1)$$

$$U_{\text{grav}} = -\frac{3}{5}G\frac{(2M_\odot)^2}{10^4\,m} \simeq 4\cdot 10^{46}\ J$$

$$2M_\odot c^2 \simeq 4\cdot 10^{47}\ J$$

$$\left.\begin{array}{l} M_{core} > 2M_\odot \longrightarrow \text{Singularity} \\ + \text{Event horizon} \end{array}\right\}\ \text{Black hole}$$

Special Relativity

0) speed of light, c, is the same in all inertial systems

1) relativity of Simultaneity

2) "time dilation"

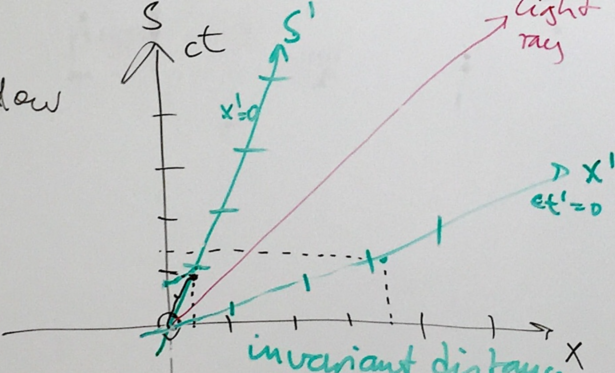
according to S, the clock in S' goes slow

3) "length contraction"

rentz $ct' = \gamma\left(ct - \frac{v}{c}x\right)$

q.8.

$x' = \gamma\left(x - \frac{v}{c}ct\right)$



invariant distance

$\Delta s^2 = (\Delta ct)^2 - (\Delta\vec{r})^2$ Same in all coordinate systems

IF $\Delta ct = 0 \rightarrow \Delta\ell = \sqrt{-\Delta s^2}$ $\quad \underbrace{\Delta x^2 + \Delta y^2 + \Delta z^2}$ $\rightarrow$ space-like separation $\Delta s^2 < 0$

$\tau = \frac{\sqrt{\Delta s^2}}{c} \Leftarrow$ IF $\Delta\vec{r} = 0 \rightarrow \Delta ct = \sqrt{\Delta s^2} \rightarrow$ timelike separation $\Delta s^2 > 0$

proper time

if $|\Delta\vec{r}| = ct \rightarrow \Delta s^2 = 0 \longrightarrow$ light-like separation

r, φ

$ds^2 = dr^2 + r^2 d\varphi^2$

$g = \begin{pmatrix} 1 & 0 \\ 0 & r^2 \end{pmatrix}$

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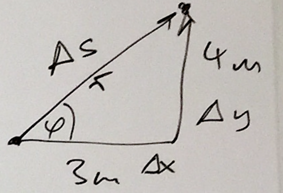

$\Delta s^2 = \Delta x^2 + \Delta y^2$

$g = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$

$\Delta s^2 = (\Delta ct, \Delta\vec{r}) \begin{pmatrix} & \\ & \end{pmatrix} \begin{pmatrix} \Delta ct \\ \Delta\vec{r} \end{pmatrix}$