

QUESTIONS

- 1) What's "special" about S.R.?
- 2) Why use c to convert time to space?
- 3) How to express G.R. in equation

special relativity: flat space-time
length, time, mass
vary with velocity
Some things are INVARIANT

for points on 2-D space

Δx varies
 Δy varies

$$(\Delta x)^2 + (\Delta y)^2 = (\Delta D)^2$$

invariant

"event" in space-time

3 spatial coord
1 time coord

velocity change

distance } change
time }

$$(\Delta s)^2 = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - c^2(\Delta t)^2$$

invariant interval

interval can be zero, -ve, +ve

if interval is zero:

distance in light years
= time separation in years

if emit a photon at one event

that photon can be present
at second event

if interval is negative:

distance < light travel time
"time-like" photon is already past 2nd event

if interval is positive

"space-like"
light photon hasn't reached event #2
can't communicate from event #1 to event #2
can't travel from event #1 to event #2



$$(\Delta s)^2 = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - c^2(\Delta t)^2$$

"METRIC" (flat space)
no mass

OR in polar

$$(\Delta s)^2 = (dr)^2 + R^2(d\Omega)^2 - c^2(dt)^2$$

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"Schwarzschild metric"

presence of a single
point mass at $R=0$

$$(d\tau)^2 = \frac{(dR)^2}{(1 - R_s/R)} + R^2(d\Omega)^2$$

$$- c^2(1 - R_s/R)(dt)^2$$

$$R_s = \frac{2GM}{c^2}$$

if $R_s/R \rightarrow 0$
metric \rightarrow flat

if $M \rightarrow 0$, $R_s \rightarrow 0$ \uparrow
or if $R \rightarrow \infty$ $R_s/R \rightarrow 0$

$R \rightarrow R_s$ $(1 - R_s/R) \rightarrow 0$

(dR) term gets big

(dt) term gets small

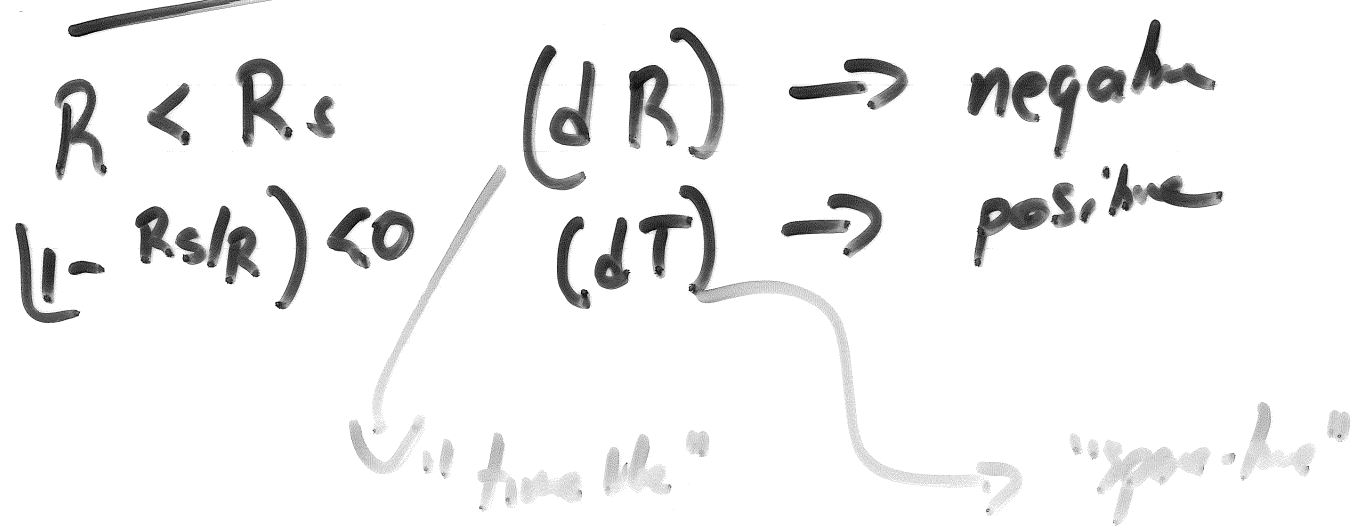
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ALL INTERVALS BECOMING
"space-like"

cannot communicate or travel
 over space-like intervals
 can't cross $R = R_s$

$$(dT)^2 = \frac{(dR)^2}{1 - R_s/R} + R^2 (d\Omega)^2 - c^2 (1 - R_s/R) (dt)^2$$



Can only travel
 -ve intervals
 motion in R is required $R < R_s$
 motion in T is required $R > R_s$
 "space & time reverse"



two points x, y, z, t

$$(\Delta s)^2 = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - c^2 (\Delta t)^2$$

↑
is invariant

EVIDENCE FOR G.R. FROM ASTRONOMICAL OBJECTS

orbit of Mercury

19th century: orbit of Uranus

→ presence of an unknown planet
→ predicted presence of Neptune
discovered it in predicted place

orbit of Mercury also perturbed
predict presence of "Vulcan"
look for Vulcan → ~~FIND IT~~
(many times) → ~~all different~~

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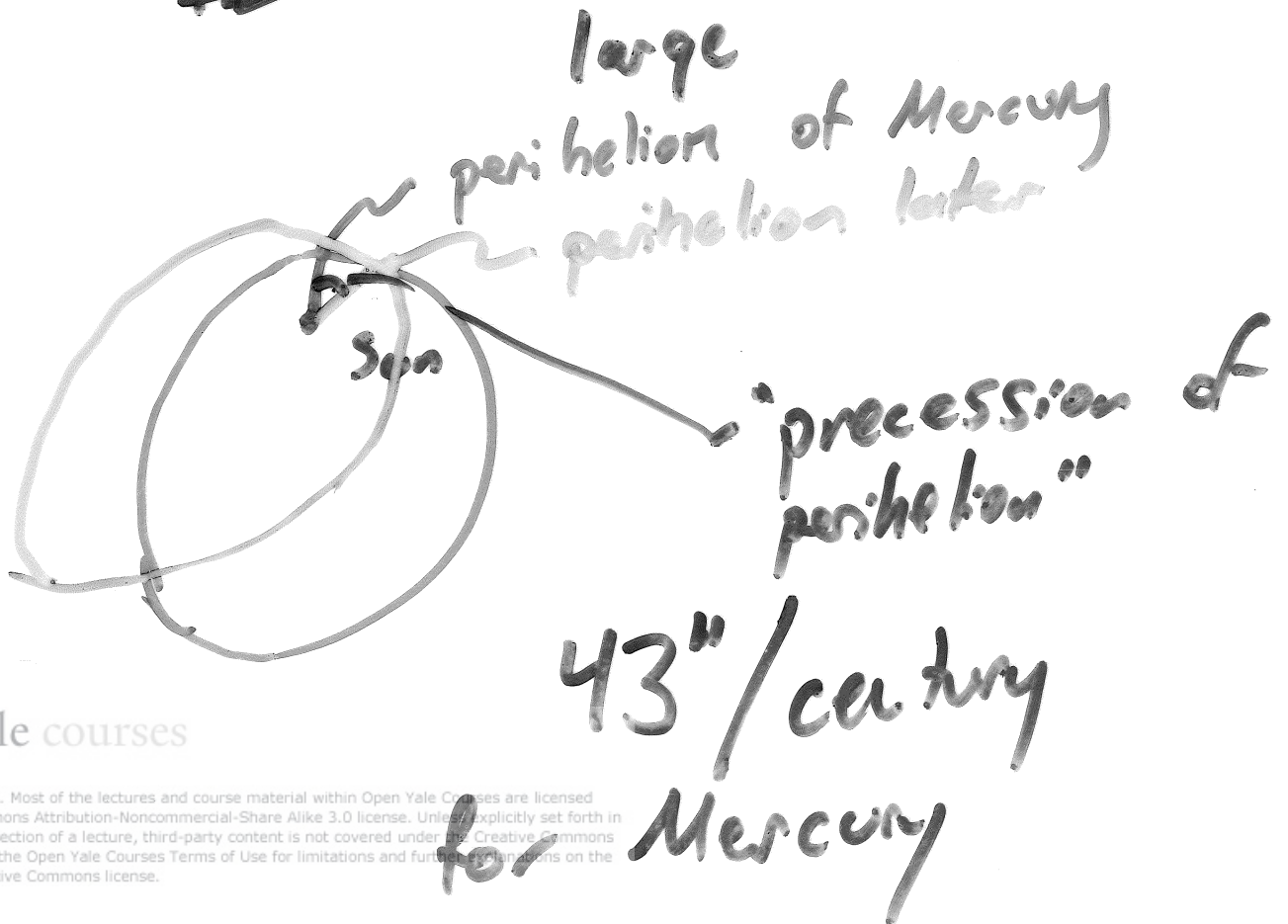
not really

Einstein creates new theory
of gravity

→ Mercury's orbit now
agrees w/ observation
without new planet

for Mercury \uparrow R_s/R is
Sch. of Sun biggest in
solar system

~~the~~ G.R. effect are
large



FABLE: Einstein & prec.
of perihelion

MORAL: { aesthetic considerations
 { philosophical
 { can lead to a good
 { new theory
 { ONLY for G.R.

SINCE Then, a variety
of tests of G.R.

PASSES ALL OF
THEM