PHYSICS 161

Homework no. 1: Due Thurs. Jan. 26

1

Hartle chp.3, prob 2

2

The *spacetime interval*, Δs, between two events with coordinates

$$(x_1, y_1, z_1, t_1) \text{and} (x_2, y_2, z_2, t_2)$$

is defined by

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

(a) Use the Lorentz transformations given in class to show that Δs has the same value in all inertial reference frames. The spacetime interval should be *invariant* under Lorentz transformations.
(b) If $(\Delta s)^2 < 0$, then the interval is *timelike*. Show in this case,

$$(\Delta \tau)^2 = -(\frac{\Delta s}{c})^2,$$

where $\Delta\tau$ is the proper time interval between two events.
If $t_1 < t_2$. could the first event possibly caused the second event?
(c) if $(\Delta s)^2$=0, the interval is *lightlike*. Show that only light could have traveled between the 2 events. Could the first event have possibly cause the second event?
(d) If $(\Delta s)^2 > 0$, then the interval is *spacelike*. Could the first event have caused the second event?

3

τ Ceti is the closest single star that is similar to the sun. At time t=0, Alice leaves Earth in her starship and travels at speed of 0.95c to τ Ceti which is 11.7 light years away as measured by astronomers on Earth. Her twin brother, Bob, remains at home, at $x = 0$
(a) According to Bob, what is the interval between Alice's leaving Earth and arriving at τ Ceti ?
(b) According to Alice, what is the interval between her leaving Earth and arriving at τ Ceti?
(c) Upon arriving at τ Ceti, Alice immediately turns around and returns to earth at speed of 0.95c (assume turn around time is 0 seconds).What is the proper time for Alice during her round trip to τ Ceti.
(d)When she and Bob meet on her return to earth, how much younger will Alice be than her brother?

4

(a) Suppose O' observer moves with velocity U along positive x axis with respect to O observer. Use inverse Lorentz transformations $(x', t') \rightarrow (x, t)$ to show how x velocity of particle in O' frame, v' appears in O frame. Use the inverse Lorentz transformations given in class to work out addition law of velocities.
(b) Suppose $v' = c$. What is velocity of particle in O frame?

5

Hartle, problem 4.2