PHYS 1512: Week 11

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Equations

$$\Delta t = \frac{\Delta t_o}{\sqrt{1 - \frac{v^2}{c^2}}} = \Delta t_o \gamma \quad \text{(Time Dilation)} \tag{1}$$

$$L = L_o \gamma \quad \text{(Length Contraction)} \tag{2}$$

$$p = mv\gamma \quad \text{(Relativistic Momentum)} \tag{3}$$

$$E = mc^2\gamma \quad \text{(Relativistic Energy)} \tag{4}$$

$$E = \sqrt{p^2c^2 + (mc^2)^2} \quad \text{(Relativistic total energy)} \tag{5}$$

$$v_{AB} = \frac{v_{AC} + v_{CB}}{1 + \frac{v_{AC}v_{CB}}{c^2}} \quad \text{(Relativistic velocity)} \tag{6}$$

Some Notes

I will not cover the following equations:

$$sin(\theta) \approx \theta = 1.22\frac{\lambda}{D} \quad \text{(Resolving Power)}$$

$$sin(\theta) = m\frac{\lambda}{d}, m = 0, 1, 2.. \quad \text{(Diffraction grating)}$$

Neat observation:
Take eqn (5) from today and assume the object has no momentum whatsoever, what equation did you derive?

Question #1

Dial back the clocks

A spaceship travels at a constant speed from earth to a planet orbiting another star. When the spacecraft arrives, 12 years have elapsed on earth, and 9.2 years have elapsed on board the ship. How far away (in meters) is the planet, according to observers on earth? (in light-years)

(1 year $\approx 3.154 * 10^7$ sec)
(1 light-year $\approx 9.461 * 10^{15}$m)

Question #2

Direction matters

A meter stick has dimensions Length = 1.0m, Width = 8mm thick and Height = 25.4mm.

a) How fast must a meter stick be moving if its length is observed to shrink to one half of a meter? Leave your answer in terms of the speed of light.

b)If the meter stick moves at the same speed as in a) but now has the velocity pointed perpendicular to its width, what is the observed length from someone at rest?

c) What is the observed height for part b)?

Question #3

Faster than a speeding woman

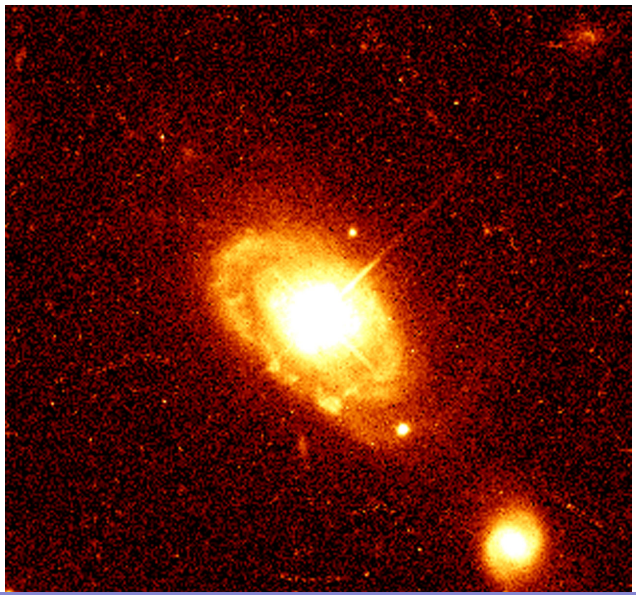
A woman is 1.6m tall and has a mass of 55kg. She moves past an observer with the direction of motion parallel to her height. The observer measures her relativistic momentum to have a magnitude of $2.0 * 10^{10} kg \frac{m}{s}$. What does the observer measure for her height?

Question #4

Einstein's insight

Quasars are believed to be the nuclei of galaxies in the early stages of their formation. Suppose that a quasar radiates electromagnetic energy at the rate of $1.0 * 10^{41} W$. At what rate (in kg/s) is the quasar losing mass as a result of this radiation?

If the sun's mass is $M_{\odot} = 1.989 * 10^{30} kg$, how long would it take for this quasar to emit 1 solar mass?



Question # 5

To boldly go

A spacecraft approaching the earth launches an exploration vehicle. After the launch, an observer on earth sees the spacecraft approaching at a speed of 0.50c and the exploration vehicle approaching at a speed of 0.70c. What is the speed of the exploration vehicle relative to the spaceship?