Phys 2053: Homework X

due April 6, 2016

1. (*2 pts*) A meter stick moves parallel to its length with speed $v = 0.5c$ relative to you.

1. How long would you measure the length of the meter stick to be?
2. How much time would it take the stick to pass by you?

2. (*3 pts*) In an asymmetric colliding beam experiment, a beam of electrons e^- strike a beam of positions e^+ traveling in the opposite direction. Suppose that the electrons are moving in the positive x-direction, and the positrons are moving in the negative x-direction. Denoting the position of an electron by x_e, the position of a positron by x_p, the position of the center of mass of an electron-positron pair by X, and the mass of an electron or a positron by m, the position of the center of mass is given by the equation

$$2mX = mx_e + mx_p. \tag{1}$$

1. Suppose the speed of the electrons is $0.95c$ and the speed of the positron is $0.2c$. Calculate the velocity of the center of mass of an electron-positron pair.
2. Suppose that the collision between an electron and a positron produce a particle at rest in the center of mass system, which decays in 2×10^{-8} s. What will the lifetime of the particle be in the laboratory frame of reference?

3. (*3 pts*) A light signal and a neutrino with energy E = 2 MeV and rest mass $m_0c^2 = 2$ eV are emitted simultaneously from a supernova, which is at a distance 10^4 light years from earth.

1. What is the difference in arrival times at earth?
2. How long does the trip take in the neutrinos rest frame?
3. What is the distance to earth as viewed in the neutrinos rest frame?

4. (*3 pts*) Doppler Shift

1. Calculate the Doppler Shift of the Sodium D_2 line with $\lambda = 589.0$ nm if the source is moving with a speed of $0.3c$ (a) towards an observer, (b) away from an observer, (c) in a transverse direction.
2. Suppose that a distant galaxy is moving away from us with a speed of 120,000 km/s. What would be the relative shift $(\lambda - \lambda_0)/\lambda_0$ of its Hydrogen α-line with $\lambda =$ 656.5 nm?