Astronomy 421 – Problem set 3

Due Thursday, Sep 15

1. A rod moving relative to an observer is measured to have its length, L_moving, contracted to one-half of its length when measured at rest. Find the value of u/c for the rod's rest frame relative to the observer's frame of reference
2. An astronaut in a starship travels to alpha Centauri, as distance of approximately 4 ly as measured from Earth, at a speed of u/c = 0.8.
   a. How long does the trip to alpha Centauri take, as measured by a clock on Earth?
   b. How long does the trip to alpha Centauri take, as measured by a clock on the starship?
   c. What is the distance between alpha Centauri and Earth, as measured by the astronaut?
3. For the situation in problem (2):
   a. A radio signal is sent from the Earth to the starship every 6 months, as measured by a clock on Earth. What is the time interval between reception of one of these signals and reception of the next signal aboard the starship?
   b. A radio signal is sent from the starship to the Earth every 6 months, as measured by a clock on the starship. What is the time interval between reception of one of these signals and reception of the next signal on Earth?
   c. If the wavelength of the signal send from Earth is 15cm, at what wavelength is it received by the starship.
4. In its rest frame, quasar Q2203+29 produces a hydrogen emission line of wavelength 121.6 nm. Astronomers on Earth measure a wavelength of 656.8 nm for this line. Determine the redshift.
5. The quasar 3C 446 is violently variable; its luminosity at optical wavelengths has been observed to change by a factor of 40 in as little as 10 days. Using its known redshift, z = 1.404, determine the time for the luminosity variation as measured in the rest frame of 3C 446. What does this imply about the minimum size of the optical emitting region?
6. Sirius is a visual binary with a period of 49.94 years. Its measured trigometric parallax is 0.37921 +/- 0.00158 arcsec, and assuming that the plane of the orbit is in the plane of the sky, the true angular extent of the semimajor axis of the reduced mass is 7.61 arcsec. The ratio of the distances between Sirius A and Sirius B from the center of mass is a_A/a_B = 0.466.
   a. Find the mass of Sirius A and the mass of Sirius B.
   b. The absolute bolometric magnitude of Sirius A and B is 1.36 and 8.79 respectively. Determine their luminosities in units of solar luminosities.
   c. The effective temperature of Sirius B is approximately 24,790 K +/- 100K. Estimate its radius and compare your answer to the radius of the Sun and the radius of Earth.
7. From the light and velocity curves of an eclipsing, spectroscopic binary system it is determined that the orbital period is 6.31 yr, and the maximum radial velocities of Stars A and B are 5.4 km/s and 22.4 km/s respectively. Furthermore the time period between first contact and minimum light (t_b – t_a) is 0.58 days, the length of the primary minimum (t_c – t_b) is 0.64 days, and the apparent bolometric magnitudes of maximum, primary minimum, and secondary minimum are 5.4 mags, 9.2 mags, and 5.44 mags respectively. From this information and assuming circular orbits, find:
   a. Ratio of stellar masses M_A/M_B
   b. Sum of the masses (M_A + M_B) assuming an edge-on system.
   c. Mass of stars A and B in solar masses.
8. Based on the information in problem 7 above find:
   a. The radius of stars A and B
   b. The ratio of effective temperatures for stars A and B (T_A/T_B)
9. Give two reasons why the radial velocity technique for detecting planets around other stars favors massive planets (e.g. Jupiter) with relatively short orbital periods.
10. Suppose you observe a superluminal jet with an angle to the line of sight of 10 degrees and a Lorentz factor of 6. What is the apparent velocity as a fraction of the speed of light (β_{app})? What is the true velocity of the jet (β)?