Astro 7B: Homework # 1

Problem 4.4

A rod moving relative to an observer is measured to have length $L_{\text{moving}}$ contracted to one-half of it’s 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.

Problem 4.6

An astronaut in a starship travels to α Centauri, a distance of approximately 4 ly as measured from earth, at a speed of $u/c=0.8$

(a) How long does the trip to α Centauri take, as measured by a clock on Earth?

(b) How long does the trip to α Centauri take, as measured by the starship pilot?

(c) What is the distance between Earth and α Centauri, as measured by the starship pilot?

(d) A radio signal is sent from Earth to the starship every 6 months, as measured by a clock on Earth. What is the time interval between reception of one of this signals and reception of the next signal aboard the starship?

(e) A radio signal is sent from the starship to the Earth every 6 months, as measured by a clock aboard the starship. What is the time interval between reception of one of this signals and reception of the next signal on Earth?

(f) If the wavelength of the radio sent from Earth is $\lambda = 15$ cm, to what wavelength must the starship’s receiver be tuned?
Problem 4.7

Upon reaching α Centauri, the starship in Problem 4.6 immediately reverses direction and travels back to earth at speed \( u/c = 0.8 \). (Assume that the turnaround itself takes zero time.) Both Earth and the starship continue to emit radio signals at 6-month intervals, as measured by their respective clocks. Make a table for the entire trip showing at what times Earth receives the signals from the starship. Do the same for the times when the starship receives the signals from Earth. Thus an Earth observer and the starship pilot will agree that the pilot has aged 4 years less than the Earth observer during the round-trip voyage.
Problem 4.8

In the rest frame, quasar Q2203+29 produces a hydrogen emission line of wavelength 126.6 nm. Astronomers on Earth measure a wavelength of 656.8 nm for this line. Determine the redshift parameter and the apparent speed of recession for this quasar.

Problem 4.9

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 the redshift parameter $z = 1.404$ measured for 3C 446, determine the time for the luminosity variation as measured in the quasar’s rest frame.