1. Say you take a spectrum of a star and determine that it is an A0 main sequence star. From the data in Table G in your book, you assert that its absolute visual magnitude is +1.1. You measure this star’s apparent V-band magnitude to be +11.10 and its observed (B-V) color to be +0.28 mag.

   a. Assuming that there is no interstellar dust dimming and reddening the light of this star, what is its distance?

   b. According to the data in Table G, such a star should have a color of (B-V) -0.02. What is its color excess E(B-V), in magnitudes? In other words, how much redder is the star’s color index than the unreddened color index?

   c. The V-band extinction is $A_V = R_V E(B-V)$. Standard dust in the plane of the Milky Way has $R_V = 3.1$ (Cardelli, Clayton, and Mathis, 1989). If this scaling factor applies to this star, what would the V-band magnitude of this star be if there were no interstellar dust dimming and reddening the star? And what would be a more accurate value of its distance?

   d. Say this star were situated in a star forming region for which $R_V = 5.0$ was the scaling factor between color excess and V-band extinction. What would this imply about the true (unreddened) V-band magnitude and distance to the star? In other words, calculate another value of the unreddened V-band magnitude and distance. Comment about the importance of the parameter $R_V$.

2. In its rest frame a quasar emits a hydrogen emission line (Lyman alpha) at a wavelength of 1216 Å (121.6 nm). Say this line is observed by us at a wavelength of 7296 Å (729.6 nm).

   a. What is the redshift of this quasar?

   b. At what fraction of the speed of light is it receding from us?

   c. Compared to the average distance between galaxies at the present epoch, what was the average distance between galaxies when the light we receive now from this quasar was emitted? This is related to the cosmic scale factor $R$. See Krisciunas (1993): http://people.physics.tamu.edu/krisciunas/1993JRASC__87__223K.pdf

   d. Hubble’s constant relates the velocity of recession of distant galaxies with their distances: $V_r$ (km/sec) = $H_0 D$, where D is measured in megaparsecs and $H_0$ ~ 72 km/sec/Mpc (Freedman et al. 2001). From equations 4b and 5 of Krisciunas (1993), estimate the look-back time to this quasar in billions of years under the assumption that the universe has very low density compared to the critical density, and no cosmological constant (i.e. the “empty universe model”).

The Balmer alpha line of atomic hydrogen is the n = 3 to 2 transition, and occurs at 6563 Å (656.3 nm).

The Brackett alpha line is the N = 5 to 4 transition, and the Brackett gamma line is the N = 7 to 4 transition of atomic hydrogen. At what wavelengths would we observe these two lines?

4. What is the de Broglie wavelength of a 75 kg sprinter moving 11 m/sec? How does that compare to the size of a proton?