ASTRO 81 - Assignment #3

due Friday of Week #3 before 5pm

To get full credit for these problems you need to show all your work. Longer problems with more sub-parts are worth more points.

1. Keck Observatory has two 10 meter diameter telescopes located 85 m apart. The UCLA Galactic Center Group observes at a wavelength of 2.2 microns.
   (a) What is the shortest wavelength that could be observed by one of the Keck telescopes without the angular resolution being limited by seeing?
   (b) What is the largest possible diameter of a ground-based telescope without Adaptive Optics that could achieve the diffraction limit at 2.2 microns?
   (c) The ideal pixel scale allows for two pixels per resolution element (i.e angular resolution). For an instrument at Keck that is behind Adaptive Optics, what is the ideal focal length if the physical scale of a pixel is 27 microns?
   (d) If you could use both of the Keck telescopes simultaneously as an interferometer, how would this affect your angular resolution? How would it affect your sensitivity (light collecting power)?

2. Once upon a time, it rained in LA. If you have two buckets – one with a 20 cm diameter and one with a 30 cm diameter – how much longer would the smaller bucket need to stay out in the rain in order to collect the same amount of rain as the other bucket? How much more rain would the larger bucket collect if they were both out for the same amount of time? Explain the relationship between telescope diameter and exposure time in this context.

3. Say you photographed the moon with a telescope that has a primary mirror diameter of 10 cm and a focal length of 200 cm. The exposure time was 0.1 seconds. To get the same quality image, what should the exposure time be if the diameter of the primary mirror were 15 cm and the focal length were 150 cm? What is the image size of the moon in each case?

4. If the sun's flux density measured at earth is $f_\odot$, what is the sun's flux density measured on Mars, in units of $f_\odot$? Please answer to one significant figure.

5. Imagine that the sun emits light which has constant specific intensity between 400 nm to 800 nm, and is zero at all other wavelengths. (This is a very rough approximation for the sun's true radiation field; we will soon discuss much better models, but for now lets just use this simple one.)

(a) What is the specific flux of sunlight at Earth (in units of $\frac{W}{m^2 Hz}$)?

(b) Calculate the sun's apparent angular diameter (in degrees) and its apparent solid angle (in steradians). You may look up the diameter of and distance to the sun.

(c) What is the specific intensity of sunlight at Earth?

6. The Sloan Digital Sky Survey (SDSS) is complete to magnitudes as faint as +22 (meaning that the survey can detect all stars brighter than 22^{nd} magnitude).

   (a) How far away would a solar-type star (i.e. a star identical to the Sun) be if it were just barely bright enough to be visible on SDSS images? Please give your answer in parsecs. (Hint: The Sun has an apparent visual magnitude of -26.75).

   (b) What is the distance modulus to the star described in part (a)?

   (c) What is the absolute visual magnitude of the sun, given the apparent visual magnitude stated in part (a)?

7. In images that the UCLA Galactic Center Group takes of the stars orbiting the black hole at the Galactic center, the brightest stars observed have an apparent magnitude in the K-band filter of $m_K = 9$. The faintest stars detected in these images have $m_K = 19$. What is the dynamic range (i.e. flux ratio) between the brightest and faintest stars in these images?

8. Does the color of a star depend on its distance? Why or why not?