Astronomy 211T **Fall 2017**

Problems for Tutorial Week #7

Telescopes and Optics

1. The Williams College 6-inch Meade apochromatic telescope has a focal ratio of f/9.

   a) What is its focal length in inches?
   b) What is the plate scale in arcsec per mm?
   c) The moon is about 30 arcmin in diameter. How big an image of the moon would the 6-inch produce?
   d) You attach a reducing lens that reduces the effective focal length to half the original value of f. What is the new f? What is the new focal ratio? How big is the new image of the moon?

2. The 24-inch DFM on the roof has a focal ratio of f/10.

   a) Derive the plate scale in arcsec/mm.
   b) Convert this to arcsec/pixel, given the 9 μm pixel size of our Finger Lakes PL16803 CCD.
   c) How well does this sample pixel size the seeing here (5" typically)?
   d) Why do we almost always bin our CCD observations 4x4 on the 24-inch? Can you think of any circumstances when it would be advantageous **not** to bin?

3. The galaxy M31 (Andromeda Galaxy) is 130,000 LY across at d= 2.2×10^6 LY.

   a) What is its angular size in degrees?
   b) What would its diameter be in the focal plane of the 24-inch telescope? (It has an f/ratio=10)
   c) How long a focal length would you need in order to fit the image of the Andromeda Galaxy onto the Finger Lakes PL16803 CCD chip (4096 9 μm pixels on a side)?

4. The European ELT mirror system will have an outer diameter of approximately 39 meters, and a central obstruction diameter of 11 meters. Calculate the diameter of a gtelescope with the same effective collecting area but no central obstruction.

5. The diffraction limit of a telescope, θ_{min}, is typically written as 1.22 λ/D where λ and D must be in identical units. But then θ_{min} comes out in radians, which is not very intuitive. Show that the diffraction limit. θ_{min}, expressed in arcseconds, is roughly ¼ * λ/D where λ is in microns and D is in meters.

6. Compare the diffraction-limited resolutions of the Hubble Space Telescope and the James Webb Space Telescope at a wavelength of 6000 Å.

7. You are observing with a 2-meter telescope of f/ratio=8.0, and a CCD with 15μm pixels. On one of your images, you see two stars separated by 25 pixels. What is their actual separation on the sky, in arcseconds?

8. Explain how improving the seeing at an observatory (whether by environmental controls or using adaptive optics) enables detection of fainter objects. Be specific and quantitative about the detection process and how it would be affected by improved seeing.