ASTR 8060
Homework 3
Due 08:45 CST March 10

Learning goals: practice the S/N equation to compute S/N and exposure times for common astronomical situations.

1. Show that an error of 3% in flux units is very nearly the same as an error of 0.03 magnitudes.

2. For source A from HW2 (surface brightness of 1 MJy per steradian at 5500 Angstroms), suppose that you are observing with a V filter with a CCD camera on a 2.3 m diameter telescope like WIRO. How many photons will you collect per second in a single ccd pixel assuming that the pixel equals 1 square arcsecond on the sky and assuming you have a typical V filter bandpass width. Assume that the efficiency of the camera, CCD, and all the optics is 100%.

3. If a galaxy at a distance of 10 Mpc has a monochromatic luminosity of 1038 erg s^{-1} $Angstrom^{-1}$ over the optical part of the spectrum, how many photons per second do you expect to detect with a 2.3 m telescope in the V filter, assuming your optics and CCD have a total efficiency of 50%? Assume you observe your source at 2 airmasses.

4. If a point source has a total count rate of 0.2 ph s^{-1}, the sky background has a count rate of 0.5 ph s^{-1} $pixel^{-1}$, the dark current is 10 electrons $hour^{-1}$ $pixel^{-1}$, and the read noise is 5 electrons, how many 1-minute exposures does it take to reach a S/N of 100? Assume the stellar PSF is distributed over 4 pixels.

5. At WIRO with the prime focus imager (a 2.3m f/2.1 telescope with 13.5 μm pixels), assuming observations are taken at 1 airmass, detector $QE = 0.90$, and other telescope efficiencies are 0.70, how long would be required to achieve a S/N of 100 on a $V = 22$ magnitude star in the V filter if the moon phase is full ($\mu_V = 20$ mag $arcsec^{-2}$)? Assume $1.1''$ seeing. The WIRO Prime read noise is 4.5 electrons $pixel^{-1}$ and the dark current is effectively zero. Compare your first answer to when the moon phase is new ($\mu_V = 22$ mag $arcsec^{-2}$, e.g. from Kitt Peak Imaging Manual). Are you detector, source, or background limited?

6. At Keck, an imager with a QE of 80% is used to image a stellar object with a S/N of 50 in 10 minutes through a narrowband filter of width 50 Å. Compute how long would be required to obtain the same S/N on WIRO using our imager with 95% QE and a broadband V filter. Assume the source noise limited case and state any other assumptions you needed to make to solve the problem.