Observational Techniques
Exercise No. 1: Photometry and Signal-to-Noise Calculation
Due date: December 14, 2008

Consider a 4-meter telescope with a f/4 beam at the Cassegrain focus, where we place a CCD with 15-micron pixels. The seeing disk at the site on a given night has full-width-half-maximun (FWHM) of $0.8''$.

1. What is the pixel scale (arcsec/pixel)? How many pixels, and how many arcseconds^2 are there in a FWHM seeing disk?

2. Find in the literature (e.g. in Allen's "Astrophysical Quantities") or on the internet the absolute Johnson magnitude, M_B, of a G0-type main sequence star (remember, absolute magnitude is defined as the magnitude that would be observed at a distance of 10 pc). What will be the observed B magnitude of such a star in the Large Magellanic Cloud (LMC; distance 50 kpc)? This magnitude corresponds to what f_ν [erg/s/cm^2/Hz] and what f_λ [erg/s/cm^2/Å] at 4400 Å? Find the photon flux [photons/s/cm^2] above the atmosphere in a bandpass of width 900 Å centered at 4400 Å, assuming the spectrum is flat in f_λ.

3. Find the photoelectron detection rate within the seeing disk from the above star when observed in the Johnson B band with the above setup. The star is observed when 30 degrees above the horizon, the B-band extinction at the site is 0.25 mag/airmass, the telescope's central obscuration has a diameter of 1 meter, the reflectivity of each telescope mirror is 95%, the transmission of the corrector lens and the CCD dewar window are 96%, the filter transmission is 80%, the CCD quantum efficiency at 4400 Å is 60%, and the effective bandpass of the filter is $\Delta\lambda = 900$ Å.

4. The sky surface brightness at the site is B is 22 mag/arcsec^2. What is the CCD's photoelectron detection rate within the FWHM seeing disk due to this background? (be careful with the meaning and manipulation of this unit of [mag/arcsec^2]; e.g., the magnitude of 2.5 arcsec^2 will be 21.)

5. Find the signal-to-noise (S/N) to which the flux from the star will be measured, within the FWHM seeing disk, in a 10-minute total exposure that is split into two sub-exposures. Read noise is 10e per pixel, flat-fielding accuracy is 0.5% per pixel.